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A Magazine of Methods for Operating Men

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C O N T E N T S

DRILLING AND PRODUCTION

	Page
Microfilming Facilitates Petroleum Engineering Field Studies *By* CARROLL V. SIDWELL	73
Drilling-Rig Layout for Water Locations in the Gulf Coast *By* I. W. ALCORN	77
Analysis of Delayed Drilling Program in Water-Flooding Project *By* PAUL M. PHILLIPPI	103
Deepening and Completing a Well in the Lisbon Field, Louisiana—A Study in Modern Cooperative Practice (Part 3) *By* PAUL D. TORREY *and* FRANK H. MILLER	118
Rotary Super-Rig of Advanced Design Is Largest in Operation *By* WALLACE A. SAWDON	153
Improved Acidizing Mixtures Speed Separation of Spent Acid and Oil *By* C. E. CLASON	166

REFINING AND NATURAL GASOLINE MANUFACTURE

The Technology of Refining Processes (Article 4) *By* ARCH L. FOSTER	88
The Compressibility of Gases (Part 4) *By* GEORGE GRANGER BROWN	132
Compact, Efficient Equipment In New Gasoline Plant *By* D. N. BARROW *and* DON ATTAWAY	159
X-Ray Method of Identifying Types of Scale-Forming Deposits *By* P. E. FITZGERALD	161

OIL AND GAS TRANSPORTATION

Latest Methods and Equipment Used in Pipe-Line Reconditioning Work *By* FRANK H. LOVE	81
Methods of Studying Microbiological Anaerobic Corrosion of Pipe Lines (Part 2) *By* RAYMOND L. HADLEY	112
Pump Station on Oil Pipe Line Designed for Ready Dismantling *By* J. C. ALBRIGHT	158
Life of Metal Pump Valves Increased by Use of Composition Disks *By* HAROLD H. YACKEY	192

GENERAL

Non-Glare Panel Aids Instrument Readings *By* CHAS. C. LYNDE	167

ENGINEERING NEWS OF INTEREST

Application of Well-Test Data to Study of a Specific Gas-Production Problem	167

OIL-WORLD EXPOSITION

Pictorial Section	25 to 48, inclusive
Daily Program of Events	50 and 51
Directory of Exhibits	53 to 70, inclusive

REGULAR FEATURES

	Page
The Course of Oil	12
Highlights in Oildom	14
Major Pipe Line Activities	16
Activities in the Oil Fields	18
Petroleum Statistics and Field Activities	20
Activities in Refining	22
The Petroleum Engineer's Continuous Tables (Installment No. 34)	137
Laugh With Barney	168
Running Tour With Men in the Industry	171 and 172
Machinery and Equipment	174, 175, 176, 177, 178, 179, 180, 181, 182, 183, 184, 185 and 186
Trade Literature	204
Book Reviews	205
Meetings	207

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The Course of Oil

By K. C. SCLATER

Nemesis of Refiner

Inorganic salts in petroleum may become a very serious detriment in refining operations. Modern refinery processes and improved equipment are accentuating trouble from this source. Compared with old methods and equipment, they are more vulnerable to trouble from even very small amounts of inorganic salts in the crude. A crude that passes pipe line requirements may contain large quantities of salts that interfere with refinery processing operations. Even what might be considered infinitesimal amounts may become quite serious sources of trouble, particularly in refineries where the daily throughput runs into thousands of barrels. How much of these salts is connate is not known, but there are many instances in which their presence in harmful quantity can be traced to contamination in bringing the oil to the surface. The presence of water in the well or in the sand may be responsible.

Were the troubles of the refiner more widely known probably greater care would be taken in producing oil from wells and its subsequent treatment to keep it as free from contamination as possible.

●

Uniform Production Standards

The Texas Railroad Commission has been giving some thought to the matter of uniform production standards for all oil-producing areas over the nation. A preliminary report prepared after an investigation of this subject emphasizes two important objectives of oil production control:

1. That each pool be limited in output to an optimum rate of flow that will insure the maximum ultimate recovery of oil consistent with economic limitations.
2. That equity in fields be achieved by operating wells in such a manner that cross-drainage of oil is minimized.

Practical and technological methods for attaining these aims are now being studied by the Commission. Authorities on reservoir control believe that a consideration of reservoir conditions is fundamental and should be the governing factor in determining the rate at which the oil should be produced. Were reservoir conditions taken into consideration in all cases the greatest ultimate recovery consistent with economy would result—provided conflicting interests extraneous to the engineering phase of the problem could be reconciled.

●

California's Proration Formula

Since June 1, 1939, a uniform formula for determining allowable well production has been adopted by all operators in California. The method of allocating the allowable production of oil per well, however, appears to be not entirely satisfactory under a continually increasing State production. Allowables of top wells are suffering a reduction at the expense of marginal wells under the new method.

The maladjustment results from the fact that the State's new oil production is greatly exceeding the decline of old wells. It is suggested that drilling of new wells should be brought more nearly into line with the decline of old wells in order to maintain a better balance; otherwise, it may be necessary to have a readjustment of allowables in that State.

Curtailment in California is entirely voluntary and the operators in that State are to be commended for the success attending their efforts since June, 1939, when the present proration formula was put into effect.

The suggestion that new drilling be governed by the decline of old wells is a constructive one that might well be considered by all States.

●

Importance of Gravel-Packing

Gravel-packing as used in oil wells is usually applied as an expedient, because wells are not completed to obtain the greatest advantages from gravel-packing. It is adopted as a last resort when sand trouble in the well is encountered.

Engineering investigation indicates that gravel-packing should have an important place in the completion of wells—much more important than that now accorded it. There is good reason to believe that in many instances were the well properly completed for a gravel-pack the additional expense in doing so would be more than justified. By enlarging the diameter of the hole in the sand for a gravel-pack, the so-called keystoning effect and friction would be greatly reduced and permit freer drainage into the well. Freedom from sand and its attendant troubles, a consequent reduction in the well-operating cost, and a greater ultimate recovery of oil would result.

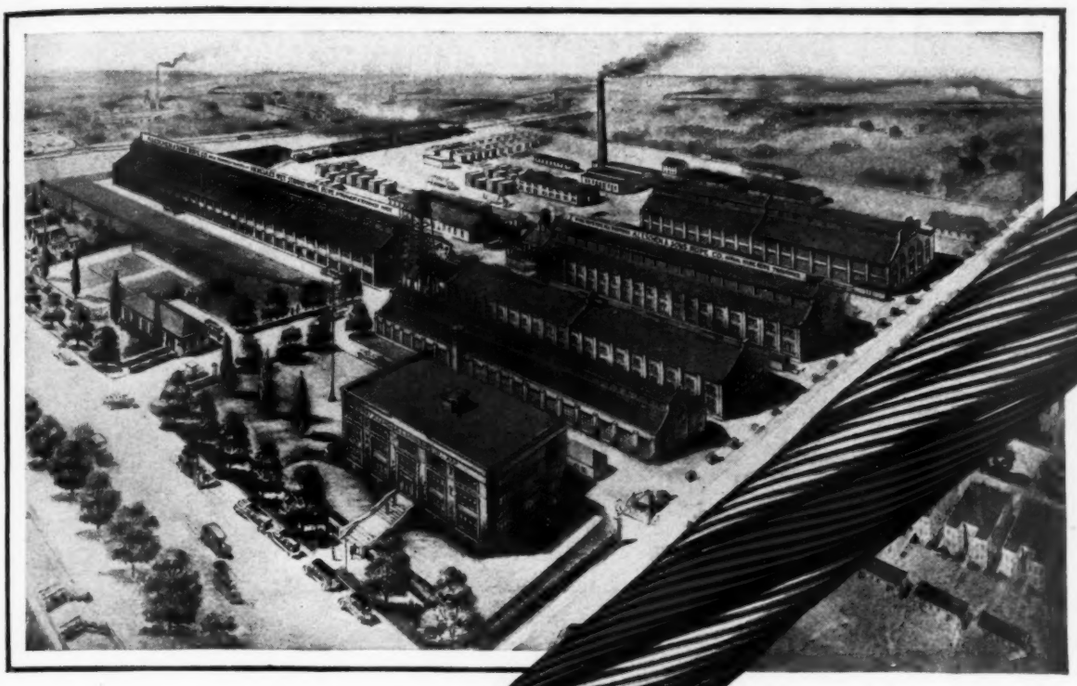
One probable reason why gravel-packing is not more widely used is the curtailment of oil production. When a well is allowed to produce in amount but a fraction of what it is capable, the operator's incentive is not too great to obtain a larger and steadier rate of flow.

Despite proration considerations, however, completion of wells with special provisions for gravel-packing should have a wider application than at present.

●

Anticipating Future Requirements

Another milestone in deep drilling equipment has been reached. Recently there was placed in operation in California a rotary drilling rig larger than any yet manufactured. Steam at a pressure of 500 pounds is the source of power. This rig is reported to be adequate for drilling a well to any depth likely to be projected in the next few years. Its operation will be followed with interest. The appearance of this equipment at this time is a demonstration of how manufacturers are anticipating future needs.



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« « HIGHLIGHTS IN OILDOM » »

Texas Commission Given Time To Appeal

A three-judge Federal Court has granted the Texas Railroad Commission an opportunity to appeal to the United States Supreme Court the ruling that would void its East Texas proration order, by its decision to stay for 60 days the issuance of an order enjoining the Commission from enforcing its proration regulations concerning Humble Oil and Refining Company and Rowan and Nichols Oil Company.

Recently the Fifth Circuit Court of Appeals at Austin, Texas, held the Commission's proration orders affecting the companies were unreasonable and would be declared void unless revised, or the case was appealed, within ten days.

●

Oil Compact Suggests 90-Day Allowables

The Interstate Oil Compact Commission, at its meeting in Oklahoma City, Oklahoma, April 5, recommended that all producing states adopt 90-day allowables based on the U. S. Bureau of Mines' estimates of market demands. In the past most states have had 30-day allowables, which, in many instances, were not based on the Bureau's estimates.

E. O. Thompson, member of the Texas Railroad Commission, who presented the plan in behalf of Lon A. Smith, chairman of that body, recommended the plan be put into effect immediately. At an executive meeting later in the day the plan was adopted unanimously.

Thompson, in presenting the plan, said its adoption would "take proration out of politics, at least in Texas," and also stated that it would be easier for oilmen to obtain 90-day loans at banks to finance operations than to obtain 30-day loans as in the past "because they would know what they could produce during that period."

The Cole Bill, "either in its present state or in a disguised state" was opposed at the meeting.

●

To Drill Five Test Wells In Cuba

After an intensive geophysical survey of potential oil-producing areas in Cuba, which The Atlantic Refining Company has been conducting for several years, a contract has been awarded to the Pioneer Drilling Company for the drilling of five test wells on the company's Cuban properties.

Officials of Atlantic now have under consideration the advisability of effecting certain joint-interest arrangements with other American oil companies, under which its test drilling program might be considerably expanded.

Atlantic has recently acquired two groups of titled concessions, one from the Cuban Oils Company and one from the Havana Oil Company, which it has added to its original properties consisting of several hundred thousand acres of titled concessions in Pinar Del Rio, Havana, Matanzas, Santa Clara, and Camaguey provinces. The five test wells definitely scheduled will be drilled at selected sites in its holdings.

Concurrently with the drilling program, Atlantic is continuing its geophysical survey and study of Cuba's potential oil-producing areas. The company now has two seismograph crews and one gravimeter party in the field.

●

Number of Recycling Plants In Sharp Increase

The number of recycling plants in the State of Texas doubled during 1939 and the volume of gas treated almost quadrupled, John E. Taylor, chief supervisor of the Texas Railroad Commission's Oil and Gas division, stated in summarizing gas operations last year.

"A substantial portion of the gain in sweet gas volume may be attributed to recycling and repressuring plant activities," Taylor said.

"In 12 months, the number of plants doubled and the volume of gas treated almost quadrupled as the process passed from an experimental stage and small units into an accepted and proven type of operation utilized by plants with capacities up to 100,000,000 cu. ft. daily."

In January, 1940, there were 22 plants in operation with connections to 90 gas wells and using 41 injection wells. This number of plants processed an average of 483,738,000 cu. ft. of gas per day from which 8440 bbl. of condensate are recovered each day. Of the gas used, 449,950,000 cu. ft. was used in repressuring.

●

New, Proved Petroleum Reserves Total 2,399,122,000 Bbl.

New, proved petroleum reserves totaling 2,399,122,000 bbl. (nearly double the amount of oil produced in 1939), were discovered or developed in new and old oil fields of the United States during 1939, according to a report of the American Petroleum Institute's Committee on Petroleum Reserves.

The net increase of 1,134,866,000 bbl. in known underground stocks of petroleum, after deducting the 1,264,256,000 bbl. of oil produced in 1939, increased the January 1, 1940, proved-reserve inventory to a new record total, 18,483,012,000 bbl. This total, the committee emphasized, represents only a conservative estimate by the many geologists and petroleum engineers who participated, of the reserves already proved by drilling, and recoverable by present production methods. No estimates are included for oil that still is to be found in areas known to be favorable to the accumulation of oil, but as yet untested.

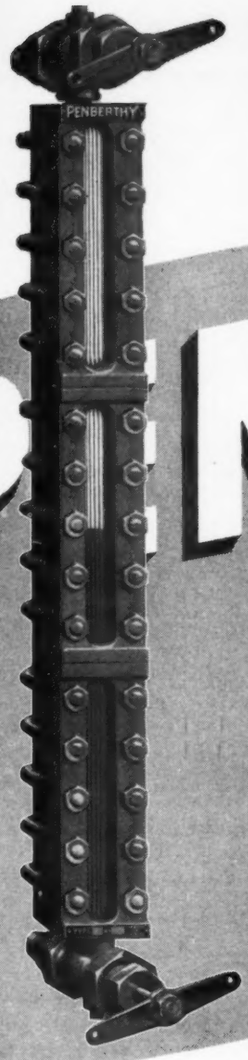
New pools and new producing horizons discovered in 14 states last year gave the nation a minimum of 340,667,000 bbl. of new reserves, the committee stated, adding that "pools tested by only one or two wells have been assigned relatively low reserves that may be considerably augmented by later development.

Development and extension of fields discovered prior to January 1, 1939, accounted for most of 1939's new reserves. Upward revision of previous estimates of reserves in these fields added 2,058,455,000 bbl. to proved U. S. oil reserves in 1939.

The greatest increase in reserves, according to the report, was in Texas, which added 805,134,000 bbl. of the total. Texas also leads all other states in total reserves, its already proved petroleum resources amounting to more than one-half of the total for the United States. California, with 567,933,000 bbl. of new reserves discovered or developed in 1939, was second.

Third largest gain was recorded in Illinois, where developments in 1939 added 233,091,000 bbl. to the previous total. Proved reserves for the state on January 1, 1940, were estimated by the committee at 381,636,000 bbl. Two years ago, on January 1, 1938, total reserves then known amounted to 40,884,000 bbl. New reserves of more than 100,000,000 bbl. also were developed in each of three other states last year: Arkansas, Kansas, and Louisiana.

Two states, Mississippi and Nebraska, in which commercial quantities of oil were discovered late in 1939, entered the reserve estimate for the first time. Proved reserves in the new pools in these states, still incompletely developed, conservatively were estimated by the committee at 6,800,000 bbl.



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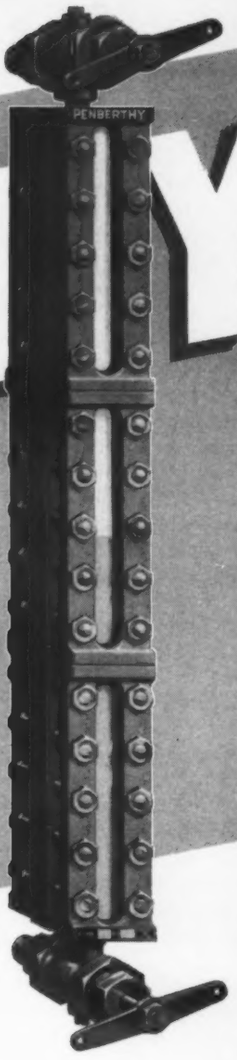

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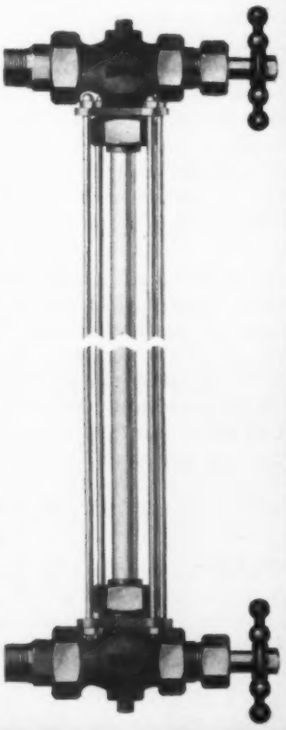

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Major Pipe Line Activities

SHELL Pipe Line Company has announced its plan to construct 85 miles of 6-in. gasoline pipe line in Massachusetts. The line will originate at Shell's marine terminal and tank farm at Fall River, Massachusetts, and extend northward to Sherborn. At the latter town, the line will branch, one line going to West Boylston and another terminating at Waltham, on the outskirts of Boston. The present schedule calls for construction of the line to start during the first half of May; 90 days are estimated as the time required to complete the work.

●

Sinclair Prairie Pipe Line Company has completed its new 8-in. pipe line from the main pump station north of Kadane corner in the K.M.A. field, southern Wichita County, Texas, to the Hensley station southeast of Jacksboro in Jack County. The line, 67 mi. in length, will also serve the Hull and Silk pool of northern Archer County. The 8-in. line is an additional line paralleling the 6-in. line completed by the same company between the same terminals about six months ago. Both lines are expected to operate at full capacity.

●

It is reported that Northern Natural Gas Company is planning to construct a new booster station this Spring in the Hugoton gas field of western Kansas. Site for the proposed station has not been selected but it will probably be near the company's gasoline plant, three miles east of Hugoton.

●

Williams Brothers Corporation has been awarded a contract by Magnolia Petroleum Company to construct five loops of 8-in. line, totaling 57 mi., between Sealy station, Austin County, and Beaumont, Texas. The additions will increase the capacity between these points from the present figure of 23,000 bbl. to 30,000 bbl. per day.

●

Construction has started on Stanolind Pipe Line Company's 134-mi. oil pipe line from the Bemis-Burnett areas of Ellis County, Kansas, to Washington, Kansas. The line, to be built of 127 mi. of 10 in. and 7 mi. of 8 in., will have a daily capacity of approximately 11,000 bbl. At Washington, the line will connect with Stanolind's main line to Wyoming.

From the Solomon River to Bemis, the line will be built by Gordon Construction Company, Denver, Colorado, and the Fredell Construction Company, Houston, Texas. From Washington to the Solomon River, the contractors are O. C. Whitaker, Inc., Fort Worth, Texas, and Brown and Root, also of Texas. J. R. Vandaveer, Neodesha, Kansas, was awarded the contract for stringing all pipe. C. S. Foreman Company, Kansas City, Missouri, has the contract for the Republican River crossing.

●

Completion of Magnolia Petroleum Company's line gives the Seminole pool of central Gaines County, Texas, its first outlet for production since the pool was discovered in January, 1937. The completed line, 26 mi. of 8 in., will be supplied with oil by two gathering systems in the pool. One system, constructed by Magnolia, is a gravity system comprised of 10 mi. of 8-in. and 10-in. lines, and 4-in. laterals. Atlantic Pipe Line Company, through 10 mi. of 6-in. and 4-in. gathering lines, is accepting oil from all wells in the north half of the pool through 2-in. connections.

●

Reliable sources report that the long-talked-of oil pipe line to cross Mexico is actually being built. The line is to cross the Isthmus of Tehuantepec from Minatitlan on the Gulf side of the isthmus to Salina Cruz on the Pacific, a distance of 303 kilometers (188 miles). It is also reported that a 10-man delegation from Mexico has sailed for Japan to enter into negotiations with the latter country seeking an increase of trade between the two countries, presumably of oil to be transported through the line when completed.

●

The new Wade City field in Jim Wells County, Texas, is to have three pipe-line outlets for oil produced in the field. Continental Oil Company plans to extend its existing pipeline system in Jim Wells County north to the Wade City field. C. Andrade and others are now negotiating for a crude oil supply, following which they will build a line into the field. Southern Minerals Corporation is now constructing a 10,000-bbl. storage tank and laying gathering lines to various leases. The latter company will build a line south from the field to the Reynolds field, where it will tie-in to the company's main line to Corpus Christi.

●

H. C. Price Co. of Bartlesville, Oklahoma, announces that it has been awarded the contracts for electric welding on the following pipe lines:

For Illinois Pipe Line Company, 40 miles of 10-in. from Martinsville, Illinois, to Brownstown, Illinois. The general contractor is Sheehan Pipe Line Construction Company.

For Tuscarora Pipe Line Company, 30 miles of 8-in. near Allentown, Pennsylvania. The general contractor is Superior Construction Company.

For Buckeye Pipe Line Company, 55 miles of 10-in. from Cygnet, Ohio, to Lima, Ohio. The general contractor is Sheehan Pipe Line Construction Company.

For Michigan Gas Transmission Company, 60 miles of 24-in. near Zionsville, Indiana. The general contractor is T. R. Jones, Inc.

●

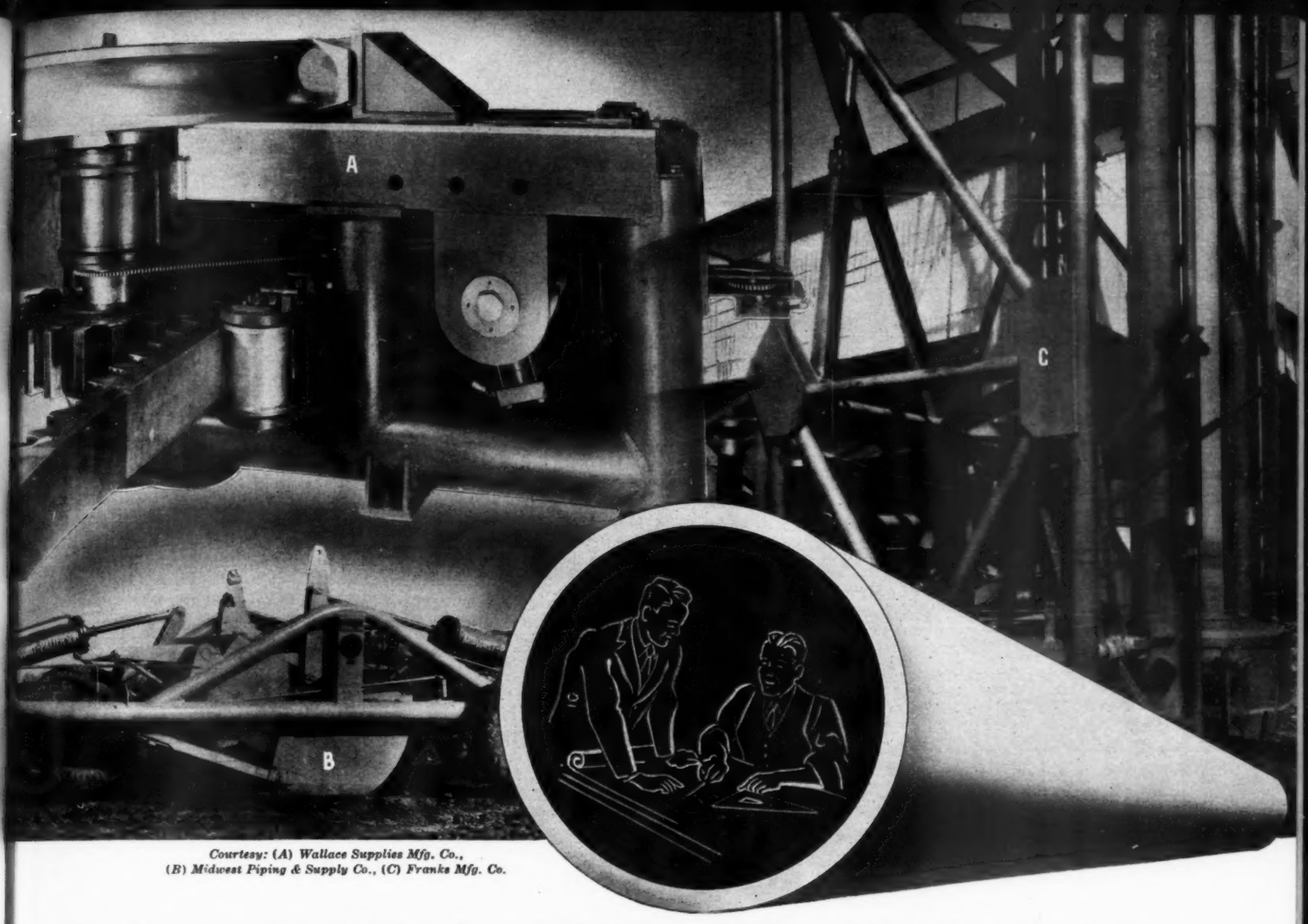
Northern Natural Gas Company, a wholly-owned subsidiary of Franco Oils, Ltd., has been awarded a 20-year franchise to supply the community of Saskatoon, Saskatchewan, Canada, with natural gas from the Lloydminster gas field. Under the franchise, the company will construct a 169-mile line from the Lloydminster field to the city of Saskatoon. Survey of the line is under the supervision of Frank Fisher, Detroit, Michigan, and Herbert Davis, Buffalo, New York, chief engineer of the project. Plans call for completion of the pipe line and a part of the distribution system by November 1. Cost of the construction is estimated to be approximately $4,000,000.

●

The Lone Star Gas Company, Dallas, Texas, has announced that it will construct an 8-in. welded line from Page field to San Angelo, Texas, to supply gas required under Cooper Gas Company's contract to supply the fuel requirements of the West Texas Utilities Company, Dumas, Texas. The Cooper Gas Company recently contracted for the purchase of holdings in the Page field from the Lone Star Gas Company. As a part of the contract, Lone Star agreed to construct the line. The new line, to cost an estimated $300,000, will have a capacity of approximately 5,000,000 cu. ft. per day.

●

Northern Pipe Line Company plans to build a 100-mile natural gas pipe line from Casper to Buffalo, Wyoming. The line will consist of 65 miles of 6-in. and 35 miles of 4-in. pipe, and will operate at a pressure of 600 lb. per sq. in. The new line will deliver gas purchased by Northern Pipe Line Company from the Northern Utilities Company to the Montana-Dakota Utilities Company at the Billy Creek field near Buffalo.



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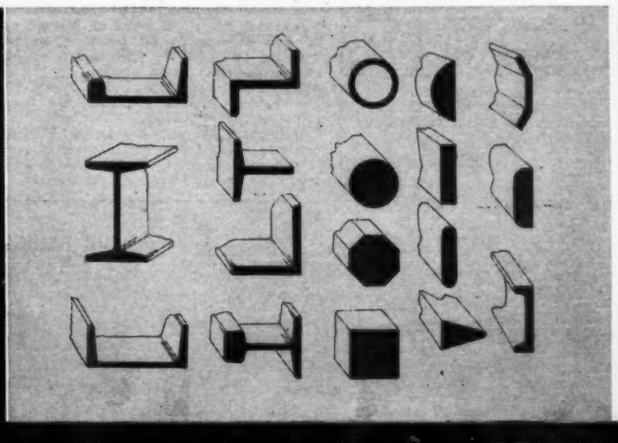
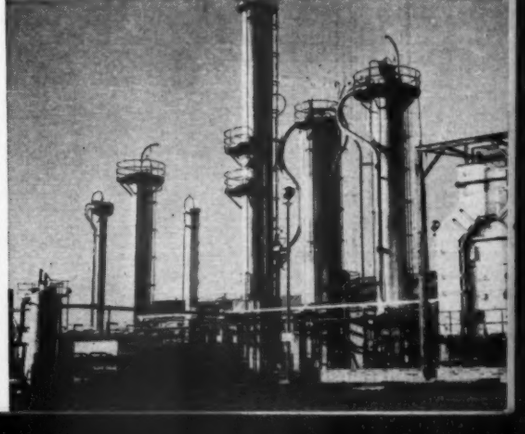


REFINING PROGRESS. New Dubbscracking unit put into operation recently at Wilmington, Calif., by Fletcher Oil Co., Inc. Construction by Fluor Corp., Ltd. Practically 100% welded with Lincoln *"Shield-Arc"* Welders and "Fleetweld" Electrodes.



Activities in the Oil Fields

A NEW Wilcox discovery for Louisiana was obtained in Atlantic Oil Company's test just north of the town of Neale, Louisiana, in Beauregard Parish. Production is through perforations at 8854-70 ft.

The discovery is important because it opens the third area in Louisiana producing from the Wilcox formation. Following discovery of Eola and Ville Platte, the other two Wilcox areas in Louisiana, the interest stimulated at the time has since lagged. The new discovery may revive search for further Wilcox production.

●

Portable Drilling Company's No. 1 Teeter, NWC SW 24-17-2e, Lincoln County, Oklahoma, sprayed oil and gauged 20,000,000 cu. ft. of gas from the Hunton limestone, logged between 4490 and 4520 ft. depths. This well opens a new pool. The well had been abandoned by other operators at a depth of 4779 ft., but by perforating the casing at strategic points, the new owners were able to obtain promise of a producer.

●

No. 1 Triplett, drilled by T. D. Humphrey in the southeast corner of J. J. Hughes survey 201, Jones County, Texas, is the discovery well of a new pool in the Cook sand. The well flowed into the pits as the sand at depths of 2184 to 2192 ft. was being drilled, and before casing could be set.

●

No. 1 Wilburn, a wildcat drilled by Kingwood Oil Company and Exchange Oil Company approximately 28 miles northeast of the Tinsley Dome field, Yazoo County, Mississippi, recovered 930 ft. of 38° A.P.I. oil in a 10-min. drill-stem test, to give a good indication of a new producing area for Mississippi.

The test was made at a total depth of 4892 ft. in a sand identified as either the lower Eutaw or upper Tuscaloosa.

The well is in NE 31-12n-3e near the junction of Yazoo, Holmes, and Madison counties. The test was made on the basis of a reflection seismograph survey that showed a reported closure of 150 ft.

●

Fortner et al No. 1 Calvin, NEC SW 9-4s-14w, in the Grayville area, White County, Illinois, is the discovery well of a pool to be known as the Calvin. At a depth of 2723 ft., an initial production of 55 bbl. in 21 hr. was obtained from the Bethel (Benoist) sand.

●

Continental Oil Company's No. 1 Nibletts in the Hayes area, Jefferson Davis Parish, Louisiana, flowed 50 bbl. in 12 hr. through a 9/64th-in. choke from a depth of 11,604-24 ft. This discovery opens a new area for Louisiana. The only other deep wells in the area were dry holes drilled by Shell Oil Company and Stanolind Oil and Gas Company in 1936 and 1937, 5 mi. and 3½ mi. southwest, respectively, of the Nibletts well.

●

North central Crockett County, Texas, was assured another new oil pool when the discovery well, Continental Oil Company et al No. 2-B Todd estate, flowed 840 bbl. of oil in 12 hr. through a 2-in. tubing string and an 11/64th-in. choke set at a depth of 5686 ft., 5½ ft. off bottom. The gas-oil ratio was 684 to 1; initial casing pressure of 900 lb. subsided during the first hour of the test to 200 lb. Production is from the Strawn limestone, penetrated at a depth of 5590 ft.

AVERAGE CRUDE OIL PRICES

California		**Louisiana**	
Kettleman Hills	$1.12-1.38	Rodessa	$1.05
Playa Del Rey	.65-1.08	Gulf Coast	.79-1.28
Coalinga	.60- .82	North Louisiana	.73-1.05
Wilmington	.64-1.14	Illinois	.95-1.05
Montana	.90-1.10	Kentucky	.90-1.10
Wyoming	.35-1.30	Indiana	.95
Colorado	.90- .98	Ohio	
New Mexico	.53- .95	Lima	.90
Texas		Michigan	.74-.97½
North Central	.71-1.03	Pennsylvania	
Panhandle	.67- .96	Bradford	2.75
West Texas	.53- .95	Southwest	2.40
Gulf Coast	.86-1.28	Eureka	2.34
Darst Creek	.96	Buckeye	2.30
East Texas	1.10	Corning	1.12
Talco	.65		
Kansas	.60-1.10	Canada	2.10-2.17
Oklahoma	.60-1.10		
Arkansas	.73-1.05		

DAILY AVERAGE CRUDE OIL PRODUCTION

Data Supplied by A.P.I.

(Figures in bbl. of 42 gal. each)

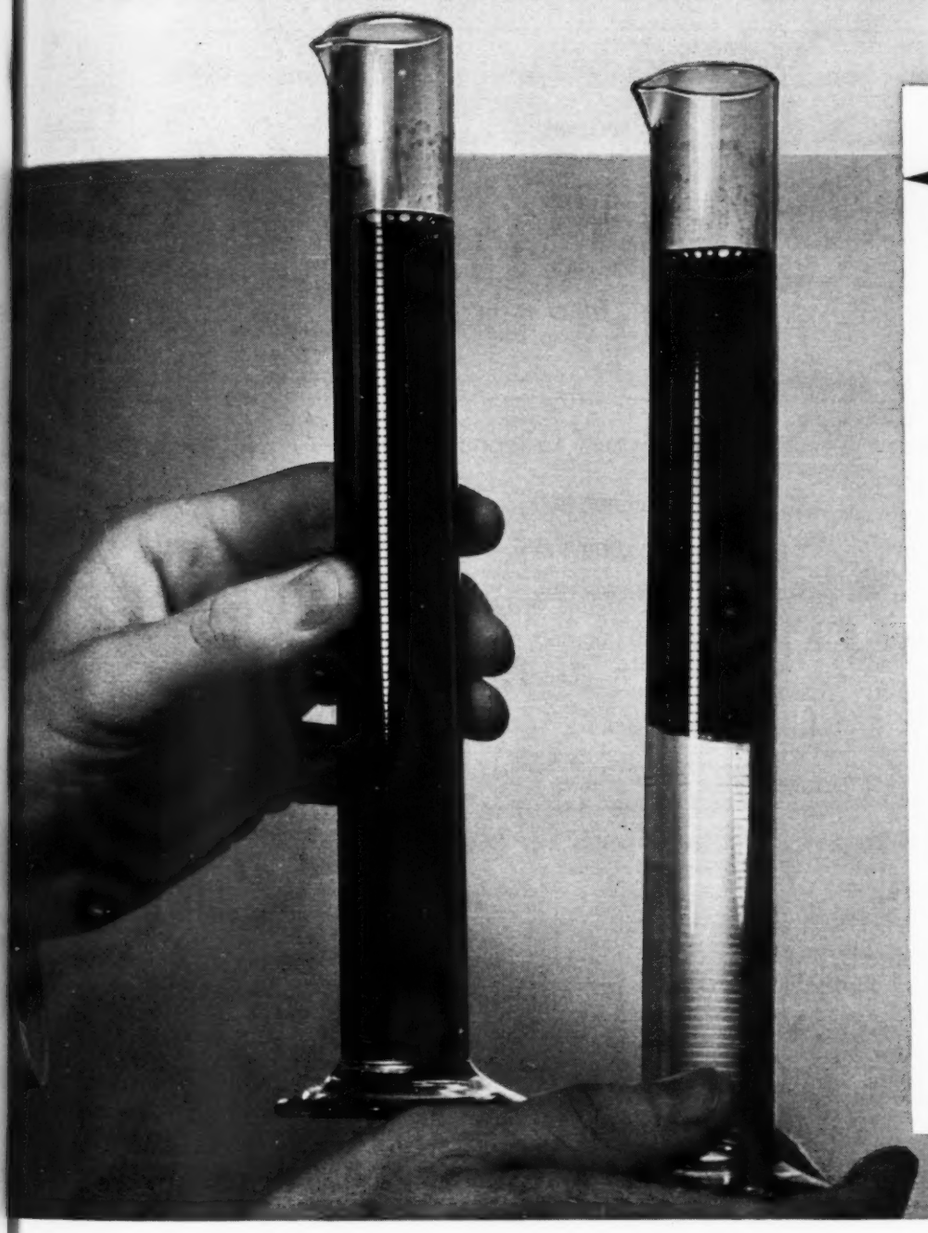
	[1]B. of M. Calculated Requirements (March)	Week Ended March 30, 1940	Week Ended March 2, 1940	Week Ended April 1, 1939
Oklahoma	420,300	[2]402,050	[3]407,550	422,200
Kansas	153,900	[2]180,400	[3]176,900	167,000
Nebraska				
Panhandle Texas		82,200	78,400	64,150
North Texas		104,600	104,650	84,300
West Central Texas		33,900	33,100	31,000
West Texas		276,650	251,600	211,650
East Central Texas		91,150	79,600	99,950
East Texas		396,900	484,000	372,700
Southwest Texas		270,350	227,950	251,400
Coastal Texas		255,050	237,650	219,300
TOTAL TEXAS	1,330,600	1,510,800	1,496,950	1,384,450
North Louisiana		68,800	69,150	69,200
Coastal Louisiana		212,900	211,900	191,200
TOTAL LA.	253,200	281,700	281,050	260,400
Arkansas	65,500	69,000	69,000	54,250
Mississippi	1,300	[2] 7,850	[3] 6,800	
Illinois	329,700	426,950	402,600	169,300
Indiana	7,100	[2] 8,500	[3] 9,650	
Eastern (Not incl. Ill. & Ind.	104,600	96,300	100,450	99,250
Michigan	64,800	64,300	63,850	58,100
Wyoming	60,600	68,750	65,200	56,150
Montana	15,200	17,000	17,200	13,250
Colorado	3,500	3,900	3,950	3,750
New Mexico	103,200	112,550	112,500	108,600
TOTAL EAST OF CALIF.	2,913,500	3,250,050	3,213,650	2,746,700
California	587,100	591,200	584,600	611,500
TOTAL U. S.	3,500,600	3,841,250	3,798,250	3,358,200

[1]These are U. S. Bureau of Mines' calculations of the requirements of domestic crude oil based upon certain premises outlined in its detailed forecast for the month of March. As requirements may be supplied either from stocks, or from new production, contemplated withdrawals from crude oil inventories must be deducted from the Bureau's estimated requirements to determine the amount of new crude to be produced.

[2]Oklahoma, Kansas, Nebraska, Mississippi, and Indiana figures are for week ended 7 a. m., March 27.

[3]Oklahoma, Kansas, Nebraska, Mississippi and Indiana figures are for week ended 7 a. m., February 28.

Increase Recovery!



Look to

DOWELL

FOR

NON-EMULSIFYING ACIDS

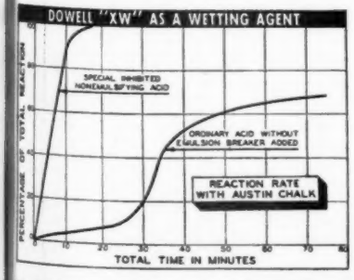
"One picture equals ten thousand words." Surely no truer words were ever spoken. For example—just take a glance at the photograph* of the two graduated cylinders. It tells an interesting and convincing story. The graduate on the left contains ordinary spent acid and an emulsifying type of crude oil. The one on the right contains spent Dowell "XW," Non-Emulsifying Acid and the same kind of crude. Convincing proof of the superior non-emulsifying properties of this treating acid.

"XW" possesses other important qualities, too. It (1) penetrates tenacious oil films faster, (2) reduces surface tension of acid and spent acid solutions, (3) enters and leaves tight formations more readily. Today the ABC's of Increased Recovery are truly elemental —simply: "Look To Dowell!"

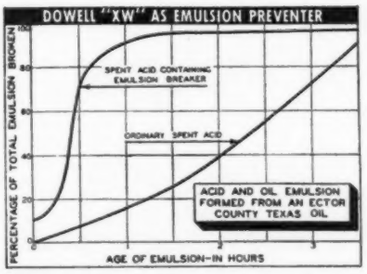
DOWELL INCORPORATED
***Executive Office:* MIDLAND, MICHIGAN**
***General Office:* KENNEDY BLDG., TULSA, OKLAHOMA**
Subsidiary of THE DOW CHEMICAL CO.

**An unretouched photograph of an actual test with Dowell "XW" conducted last month in Dowell's Tulsa laboratory.*

MENTION Chemical Service to an oil man and you're bound to start a conversation about Dowell. You will be told undoubtedly, how in 1932 Dowell pioneered and perfected Inhibited Acidizing—and about the numerous other products and services pioneered and perfected by Dowell. But these important accomplishments must be credited not to Dowell alone, but to the friendly cooperation of the oil producers and the rich background of resources, skill and knowledge which Dowell's parent organization, The Dow Chemical Company, provides. For eight years now, this unbeatable trio has been solving one problem right after another—the result: increased production and lower costs.


DOWELL "XW" AS A WETTING AGENT
PERCENTAGE OF TOTAL REACTION
SPECIAL INHIBITED NONEMULSIFYING ACID
ORDINARY ACID WITHOUT EMULSION BREAKER ADDED
REACTION RATE WITH AUSTIN CHALK
TOTAL TIME IN MINUTES

Regular acid reacts with difficulty with some oil-wet limestones but the reaction is effective when certain agents are added to lower surface tension and increase wetting ability.


DOWELL "XW" AS EMULSION PREVENTER
PERCENTAGE OF TOTAL EMULSION BROKEN
SPENT ACID CONTAINING EMULSION BREAKER
ORDINARY SPENT ACID
ACID AND OIL EMULSION FORMED FROM AN ECTOR COUNTY TEXAS OIL
AGE OF EMULSION—IN HOURS

Emulsions of crude oil and ordinary spent acid break down slowly when compared to emulsions of crude oil and spent acid containing a suitable emulsion breaker.

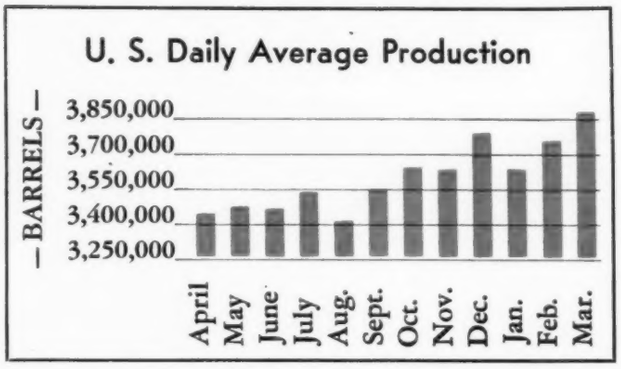
Oil men who attend the International Petroleum Exposition, which will be held in Tulsa, May 18-25, are cordially invited to visit Dowell Incorporated in its own building erected especially for the Show. Location—directly across from Cafe de Petrol.

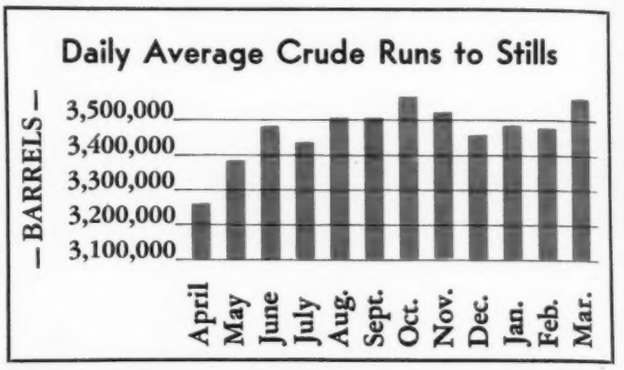
*Trade Mark Reg. U. S. Pat. Off.

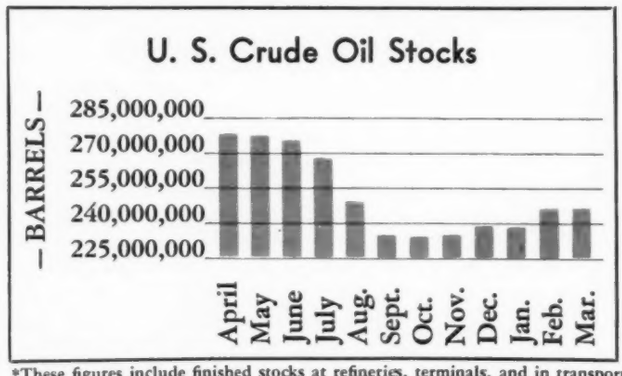
DOW SERVES THE NATION WITH CHEMICAL PRODUCTS

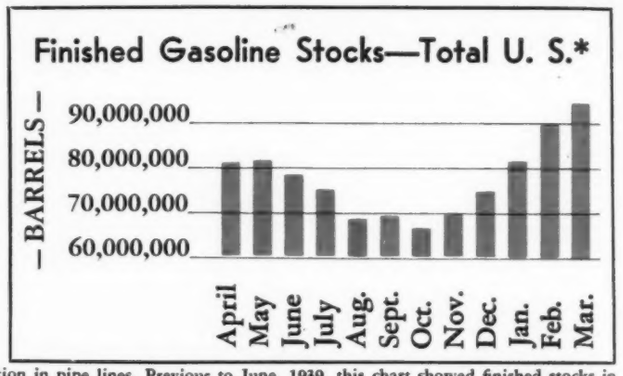
For example—Raising apples is an industry whose prosperity depends largely on controlling the destructive aphis. Dow studied the problem and, working with orchardists, developed an effective control, Dowspray Dormant.*

Petroleum Statistics and Field Activities









*These figures include finished stocks at refineries, terminals, and in transportation in pipe lines. Previous to June, 1939, this chart showed finished stocks in refineries only. Above statistics by the American Petroleum Institute.

Summarized Operations in Active Fields for March, 1940

Fields	Completions	Producers	Rigs	Drilling Wells	Depth of Production	No. Casing Strings	Gravity of Oil	Type of Tool Used
Texas								
East Texas	27	26	8	12	3500-3700	2	40	Rotary
Duval County	44	32	4	12	1554-2900	2	22	Rotary
Ector County	54	53	12	88	3675-4377	2 and 3	32-36	Rot.-Cab.
Panhandle	44	42	12	50	1700-3900	2	40	Rotary
Refugio County	4	4	2	4	4900-5900	2	38	Rotary
Nueces County	12	10	2	7	3922-5878	2 or 3	21-54	Rotary
K. M. A. Field	28	26	28	37	3730-3935	2	42-43	Rot.-Cab.
Oklahoma								
Fitts Pool	17	9	2	5	1800-4488	2 or 3	38	Rotary
Kansas								
Russell County	17	11	8	23	2926-3435	2 and 5	32-37	Rot.-Cab.
Rice County	14	9	5	20	3222-4085	2 and 5	42-48	Rot.-Cab.
Barton County	17	16	4	20	3290-3518	2	39-42	Rot.-Cab.
Illinois								
Central Illinois	300	274	325	130	1425-4100	2	36-38	Rot.-Cab.
New Mexico								
Lea County	26	25	7	59	3150-4030	3	30-34	Rot.-Cab.
California								
Kettleman Hills	2	2	0	16	8300-8730	3 or 4	40	Rotary
Wilmington	17	17	15	14	3500-4000	2 and 3	18-20	Rotary

Field Activities by States for March, 1940

State	Completions		Producers		Locations		Rigs		Drilling Wells		Production, 1939 (In Barrels)
	March	February	March	February	March	February	March	February	March	February	
Arkansas	15	14	10	10	16	9	4	3	36	35	21,266,994
California	102	89	90	83	96	87	76	70	188	181	224,336,682
Colorado	0	....	0	....	....	....	1	1	22	20	1,402,599
Illinois	300	288	274	251	277	310	325	330**	130	134	92,915,620
Indiana	32	25	24	12	....	....	5	6	66	68	1,426,000
Kansas	132	105	105	88	157	143	40	45	183	270	59,952,340
Kentucky	17	12	9	8	....	....	9	8	90	81	5,611,500
Louisiana	118	120	89	100	149	128	35	39	192	185	94,110,736
Michigan	95	103	49	66	92	68	54	60	172	175	23,185,203
Mississippi	13	12	8	7	....	....	3	4	24	20	102,918
Montana	6	5	3	4	....	....	4	5	36	38	5,901,058
New Mexico	51	62	46	54	55	46	23	20	137	135	37,453,117
New York	97*	81*	96*	75*	....	....	24	20	77	61	5,105,000
Ohio	58*	50*	50*	39*	....	....	53	55	160	171	3,157,500
Oklahoma	160	159	98	107	174	129	53	52	295	299	156,421,939
Pennsylvania	191*	204*	181*	186*	....	....	....	....	....	....	17,342,500
Tennessee	2	0	1	0	....	....	....	....	....	....	....
Texas	875	840	655	636	805	871	433	490	1371	1590	485,847,999
West Virginia	32	45	26	44	....	....	20	22	114	137	3,556,500
Wyoming	11	9	10	8	....	....	7	7	56	54	21,408,478
Total	2307	2223	1824	1778	1821	1791	1169	1237	3349	3654	1,260,504,683

*Includes water-intake and pressure wells.
**Includes 257 rigs standing and 73 rigging-up.

Get ALL the Oil

from TOP to BOTTOM with

NIXON GAS-LIFT SYSTEM

Many Nixon Surface Control Gas-Lift Systems have been installed and are economically lifting fluid "off-bottom," below the tubing packer.

Original Installation Depletes the Well

Due to the patented system of setting a series of surface controlled flow valves in the tubing, the unit can be originally installed to produce the well from its flowing stage to the stripper stage. Fluid can be unloaded through this series of flow valves, thus eliminating the necessity of swabbing before going on production.

As the flow level drops during the life of the well, each succeedingly lower valve can be operated by lowering the weight bar on its wire line, from the surface. The purchase or installation of additional equipment is not necessary. When fluid reaches the "off-bottom" production stage, the special bottom hole flow valve can be put into operation simply by placing the weight bar to operate this valve.

"Off-Bottom" Production with Lower Gas-Fluid Ratio

When producing "off-bottom," fluid-lifting gas pressure enters the bottom hole valve, when opened, and passes downward through the annulus between outer tubing and inner tubing, which extends into a fluid accumulating chamber near the bottom.

This method forces the fluid up through the macaroni tubing, instead of through the annulus between macaroni tubing and the large accumulating chamber. This reduces the input gas-fluid ratio because it prevents slippage of gas through the fluid. It also prevents excessive cutting or emulsification of the oil.

TALK TO A NIXON GAS-LIFT ENGINEER

From the highest flow level to depletion "off bottom" the Nixon System gets all the fluid. Ask one of our engineers to explain how this can be accomplished by the original installation. Write your nearest Wilson Supply Company Store or Sales Office.

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OIL & GAS WELL SUPPLIES

Complete line of Fishing Tools and Service

EXCLUSIVE GULF COAST DISTRIBUTORS FOR: Wilson-Snyder Pumps; American Cable Tru-Lay Pre-formed Wire Rope; Kewanee Boilers; Sievers Reamers; Drift Meter, Jr.; Gray Swivel; Nixon Surface Control Gas Lift; Nixon True-Taper Slip and Spider; Bowen Pack-Off and Releasing Drill Pipe Overshot; Douglas Weight Indicator; Coffey Robot Stack Draft.

BRANCH STORES:

TEXAS: Gladewater; Barbers Hill; Bay City; Monahans; Alice; Victoria; Corpus Christi.
LOUISIANA: Rodessa; Lake Charles; New Iberia; Gretna; Shreveport.
ARKANSAS: Magnolia.
SALES OFFICES: Tulsa, Okla.; Dallas, Texas. **LOS ANGELES,** Phone W.L.A. 34040.

Activities in Refining

Percent Refining Capacity Operated

Western Division, 76.3 Percent **Central Division, 79.5 Percent** **Eastern Division, 91.8 Percent**

NORTHWESTERN REFINERIES, LTD., West Vancouver, British Columbia, Canada, has been incorporated and plans to construct a refinery on the coast of British Columbia.

●

Petroleos Mexicanos, Mexican Government Agency, has announced plans for the construction of a solvent unit for refining lubricating oils at the Arbol Grande Refinery, near Tampico.

●

Inland Empire Refining Company, Spokane, Washington, has recently signed a license agreement with Universal Oil Products Company and will install a catalytic polymerization unit with a rated capacity of 500,000 cu. ft. Design and specifications for the unit will be supplied by Universal and it will be built by the Lang Company, Salt Lake City.

Inland Empire is processing 2000 bbl. of crude oil per day from the Cut Bank, Montana, field, and cracking about 1000 bbl. per day.

D. F. Gerstenberger is general manager.

●

The Panhandle Refining Company, Wichita Falls, Texas, has installed a Perco copper-sweetening unit having a capacity of 1600 bbl. per day. The unit will be operated as a solid process to treat straight-run gasoline.

●

Carter Oil Company has installed at its new Taylor plant, near St. Elmo, Illinois, a 20,000 gal. capacity copper sweetening unit.

●

Evansville Oil Corporation, Shreveport, Louisiana, is moving a 1000-bbl. refinery from Sibley, Louisiana, to Cotton Valley. The plant is expected to be in operation the early part of May. Motor fuels and solvents will be manufactured.

●

Cecil E. McNutt has made a licensing agreement with Perco, Inc., for the installation of a catalytic desulphurization unit at his Brickland, New Mexico, refinery. The purpose of the unit is to treat gasoline stocks to reduce the sulphur content.

Nathan Lynch and Associates have purchased the 5000-bbl. refinery of M. M. Travis, Inc., at Kilgore, Texas. The plant has a cracking capacity of 3000 bbl. per day. The Lynch interests also operate several other refineries in the East Texas area.

●

Work has begun on the construction of a dewaxing plant at the Sinclair Refining Company's refinery at Pasadena, Texas, on the Houston Ship Channel. The Lummus Company, New York City, is the general contractor. The plant is expected to be completed about November 15.

●

Gulf Refining Company has completed the installation of a unit at its Port Arthur, Texas, refinery, designed for the manufacture of 15,000 gal. of *iso*octane per day. The product will be blended with high-quality gasoline to produce aviation fuel. This final product will have an octane rating of about 100.

●

Rothschild Oil Company has announced plans for the installation of a Dubbs cracking unit and a catalytic polymerization unit at its Santa Fe Springs, California, refinery. The refinery is now running 3000 bbl. per day of Signal Hill and West Montebello crude oil.

The cracking and polymerization units are to be designed by Universal Oil Products Company and built by the Fluor Corporation of Los Angeles. The former is to be of 2-coil design with rated capacity of 2200 bbl. of mixed charging stock, consisting of reduced crude and kerosine distillate from Signal Hill and West Montebello crude oils.

The "poly" plant will be of size B, designed to produce polymer gasoline of 82-84 rating from 500,000 cu. ft. of cracked gas per day.

●

General Oil Corporation has completed and is now operating a new refinery at Meraux, Louisiana, near New Orleans. The capacity of the plant is 5000 bbl. of crude oil per day. It is equipped to manufacture naphtha, tractor distillate, and Diesel fuel.

Crude Runs to Stills, Gasoline, Gas and Fuel Oil Stocks
Week Ended March 30, 1940
A.P.I. Figures
(Figures in thousands of bbl. of 42 gal. each)

DISTRICT	Percent Potential Capacity Reporting	Daily Average Crude Runs to Stills	Percent Operated of Total Capacity Reporting	Total Motor Fuel Stocks	Total Gas and Fuel Oil Stocks
East Coast	100.0	595	96.7	21,430	13,316
Appalachian	87.3	124	85.5	3,959	1,081
Ind., Ill., Ky.	90.7	545	93.2	18,273	5,492
Okla., Kans., Mo.	81.6	277	81.0	9,026	2,905
Inland Texas	50.3	118	74.2	1,928	1,687
Texas Gulf	90.0	850	89.5	15,697	8,016
La. Gulf	97.8	124	70.9	3,120	1,710
No. La. and Ark.	55.0	45	81.8	695	635
Rocky Mt.	54.2	55	85.9	1,770	735
California	90.0	498	66.8	18,427	88,182
Reported	86.4	3,231	84.3	94,825	123,759
Estimated Unreported	.....	354	.....	7,045	2,600
*EST'D TOTAL U.S. MAR. 30, 1940	.....	3,585	.....	101,370	126,359
*EST'D TOTAL U.S. Mar. 23, 1940	.....	3,560	.....	101,298	126,173
U. S. B. of M. *MAR. 30, 1939	.....	**3,191	.....	87,068	135,018

*Estimated U. S. Bureau of Mines' basis.
**March, 1939, daily average.

P 948.4

THE Petroleum Engineer

APRIL, 1940

Microfilming Facilitates Petroleum Engineering Field Studies

Reduced facsimiles of original oil company records preserved on film and filed in small space, render all field and office data easily accessible for reference and study

By CARROLL V. SIDWELL
Consulting Engineer for Oklahoma City Wilcox Secondary Recovery Association

RECENT developments in the field of petroleum engineering, the exploration of new pools, the greater depths being reached daily, and the application of secondary recovery methods to the older pools, all emphasize the necessity of accurate and complete records. Past experience brings full realization of the little time and thought that has been given to the maintenance of records in the oil industry, particularly as the petroleum engineer is called upon at all times to solve various problems in which he is handicapped because of loss or inaccuracy of information, or inaccessibility of data that might be in old storage files. Coupled with the numerous difficulties is the complete inadequacy of filing systems of petroleum engineers as a whole.

"Microphotography", defined as the art or science of making small pictures of large objects, is developing rapidly and shows promise of becoming the predominant means of establishing and preserving all types of records. Application of motion picture film to this science, either in 16-millimeter or 35-millimeter size, is known as microfilming.

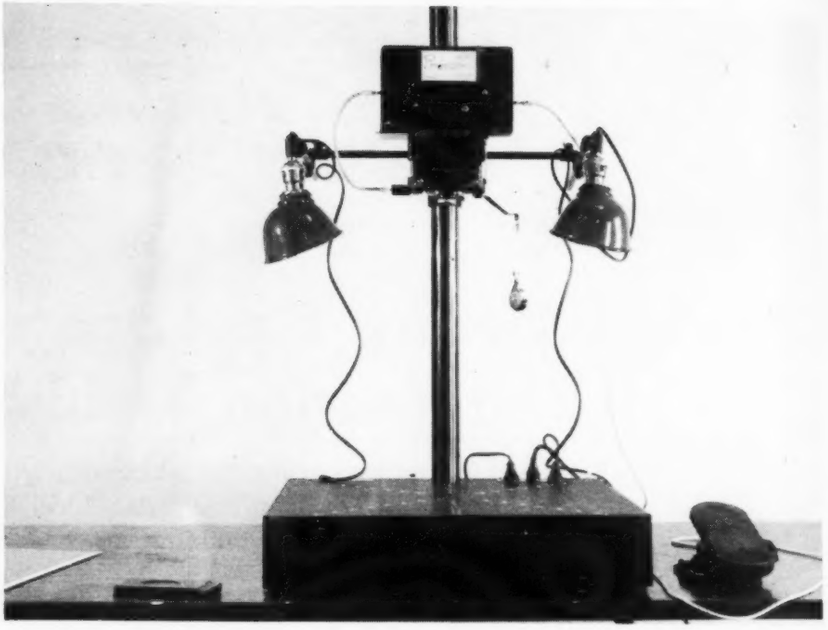
In very recent years, the American Library Association has sponsored much research work concerned with the development of equipment and methods for preserving old manuscripts and documents in various libraries of the world. Much time and expense were devoted to the work because the necessity for preserving many valuable original records, and making these easily accessible to those interested, on a more economic basis than was otherwise obtainable was fully realized. From the work originally sponsored by the American Library Association developed the American Documentation Institute at Washington, D. C., which is an organization sponsored by some 60 informational and technical societies. This Institute was formed for the purpose of making available from libraries in Washington, D. C., any published material that was in the files of any of these libraries. About two years ago, this Institute began a Bibliofilm Service, which is now prepared to supply copies of articles, manuscripts, or books in the files of all libraries in Washington, D. C., on 35-millimeter safety base film, at a cost of approximately one cent per page, plus a small service charge. There are a number of university libraries, also the New York Public Library, that have a similar service.

CARROLL V. SIDWELL

received the degree of B.S. in geology in 1923 from the University of Oklahoma, followed by a year of graduate work at the same school—After a year spent in subsurface geological work for Cortez Oil Corporation, Tampico, Mexico, devoted three years as petroleum engineer for Pan American Petroleum and Transport Company, and seven years as production engineer for Amerada Petroleum Company—From 1935 to 1937 was general superintendent of production for British-American Oil Producing Company, Tulsa, Oklahoma—After two years as an independent operator, Sidwell accepted in 1939 the post of consulting engineer in charge of field studies for the Oklahoma City Wilcox Secondary Recovery Association, work in which he is still engaged.

To give some idea of the use that has been made of microfilming, it may be well to give a short history of some of the various projects on this type of work.

There are 45 daily newspapers in the United States keeping their newspaper files on film. This is accomplished by photographing complete files by months. In addition, there are 38 daily foreign newspapers that are being photographed by the Harvard University Library and are available on film by subscription. In 1936, the New York *Times* photographed the complete file of newspapers for five years during the war, which consisted of 7229 pages. This file is available to libraries at a cost of $477. The Library



Portable photorecorder for copying records on microfilm. Note foot-switch for quick operation

of Congress installed a large high-speed machine in 1936 for the purpose of making available all information on file in that library. About the same time, the Census Bureau in Washington, D. C., installed equipment for the purpose of transferring all census records to film, making it possible to put the original records in the national archives. Since that time, various governmental libraries and other divisions of the national government have installed photographic equipment for the purpose of preserving original records. A number of industrial organizations, such as insurance companies, abstract companies, and large manufacturing concerns have transferred all obsolete files to film and keep most of their records in this manner.

The full realization of the necessity of filing, preserving, and making readily accessible the valuable records in the libraries of the world has resulted in the aforementioned organizations standardizing equipment and using microfilming as the only economical and satisfactory means for handling these records.

After a complete survey of photographic equipment for use in microfilming and the methods that have been used in other fields during the last few years, it was found that practically no application of microfilming had been used either in the oil industry as a whole or on specific engineering problems. This investigation disclosed that there are many types of equipment, all of which are satisfactory in their particular limited field. Portable cameras have been developed that permit the use of 35-millimeter film in 100-ft. rolls, and by using a photographic reduction of 12 to 1, all film will take 1600 letter-size pages per roll. There are other cameras that, though not quite so usable for voluminous work, can be adapted to the microfilming work at a very reasonable cost.

In addition, high-speed automatic machines have been developed that use either 16-millimeter or 35-millimeter film, and can be applied to voluminous work with certain limitations as to the size of the material that can be photographed.

Film used in the motion picture industry has a nitrate base and is very inflammable. When stored in closed space, this type of film may lead to the formation of explosive fumes. The need for a suitable film free from this hazard for the preservation of records led to the development of an acetate-base film. This film is no more inflammable than rag paper and is entirely safe and free from the hazard of forming explosive fumes. The least expensive film that can be used in microfilming is positive film with an acetate base, which the U. S. Bureau of Standards has determined to be as durable as 100 percent rag paper, particularly if kept under conditions of reasonable humidity. This positive film is suitable for photographing black and white or blue and white only, but not color.

Suitable panchromatic film is now available in two sizes, 16 and 35 mm., and must be used when colors are to be photographed. Color film of the Kodachrome type, though much more expensive, can be used when it is desirable to obtain color film or make color slides.

Several very satisfactory reading machines have been developed within the last two years. These might be classified in three types, such as ground glass, reflection, and projector types. The first two types are units and do not require accessory equipment. The projector type can be used either on a silver screen or on lightly colored walls. The first two classes can be used in rooms with any type of lighting system, but the latter type must be used in a darkened room for satisfactory results.

There are various methods of filing film records to make them readily accessible. Most of the files kept in other industries consist of film in 100-ft. spools; however, when numerous records and data necessary for engineering study are constantly being referred to, it has been found much more convenient to spool film in 15- or 20-ft. lengths. By the trial and error method of using the various ideas that could be obtained from previous writers on the subject, it was found that there was no satisfactory filing method that permitted the use of film in these particular lengths. Consequently, metal spools similar to the ordinary adhesive tape spools were adopted as being the most satisfactory means of indexing and handling the film. A cabinet with drawers and pegs to house these spools in any number necessary has been developed.

Petroleum engineering work frequently requires that original records from many sources must be assembled and studied in order to make a complete report of the problem at hand. Such original records usually consist of maps of various sizes, geological information such as well logs and cross-sections, and many types of production records. Invariably, the records containing this information are of different sizes, and, in many cases, only the original records are available. By microfilming such records, they can be reduced to a uniform size on a strip of film. There is little or no possibility of losing individual sheets after the material is once photographed, in which form records are virtually in a bound volume.

Frequently, photostating is resorted to in copying maps and other material when it is possible to use this type of reproduction. This process is rather costly, and, in addition, the sources of much of the information frequently are in places where photostatic equipment is unavailable. To type or copy by other means detailed information is not only costly but always entails the personal element, which may and often

Projection board for drafting maps from microfilm. Projector slides in slot. Mirror, at angle of 45 deg., can be adjusted to eliminate distortions in original map. Image is reflected onto plate glass above the mirror

does lead to inaccuracy in copying tabulations and other detailed data. By the use of microphotography, errors in transcription due to the personal element are eliminated. Indeed, the application of film to the problem of obtaining numerous facsimile records of different types and sizes is the only one that can be economically applied.

The problem of filing and preserving records is a very important one in any department of an oil company. A transfer of records to film not only is inexpensive and is cheap insurance against the complete loss of those records, but also conserves space. By transferring records to film, only two percent of the space necessary for the original files is required. In addition, if a little thought is given to the sequence in which the material is photographed, the ease of filing as compared to ordinary filing methods is greatly facilitated. The writer's experience in the handling of all types of records shows that without exception the records on film, properly filed, are much more accessible than records filed by any other method.

In the ordinary method of filing, frequently all or part of some particular file is misplaced or lost, due either to improper handling or to negligence on the part of those who have access to the files. Filing of records on film makes it possible, because of the small space in which they are contained, if filing spools are properly placed, to make a daily check of the absence of any particular spool. This is a distinct advantage and an improvement over the haphazard check usually possible in detecting the absence of any particular file from the ordinary filing cabinet.

Occasionally, original drilling and producing records of wells are changed because someone at the particular moment had some piece of information that might or might not have a bearing on the complete record. By photographing the original records at the time they are made and again, subsequent filming if necessary, all original records can be insured against alteration. In the event it is desired to preserve any original records against complete loss, a positive may be made at a small cost after the negative is developed, and this positive film stored in a vault for safe keeping, thus providing complete insurance against any loss of valuable original records.

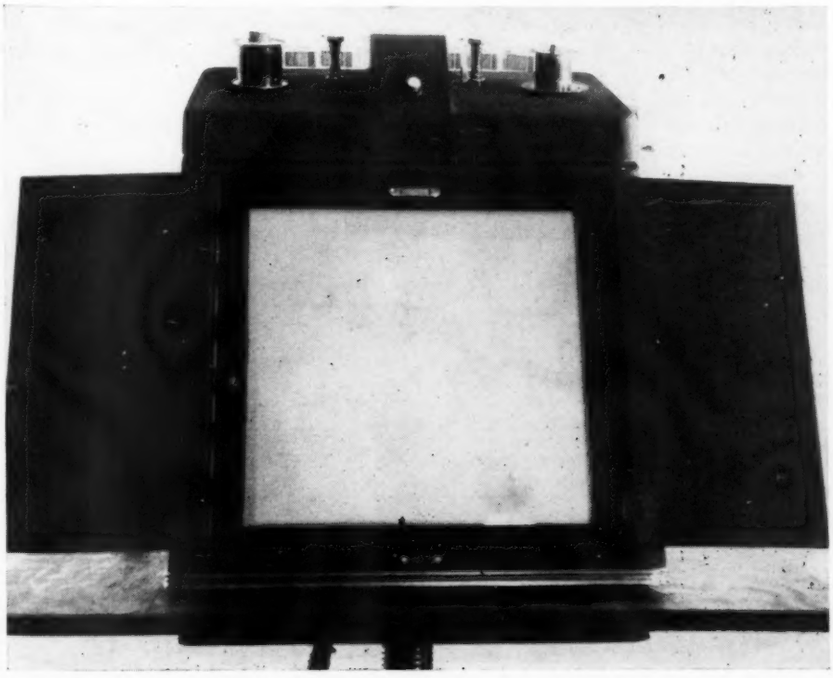
The time necessary for photographing such records is approximately one hour for 500 pages of letter, legal, or similar size material. The approximate cost, including labor, transportation, cost of film, developing, and other miscellaneous items is approximately 1½ cents per page.

Petroleum engineering phases of the oil industry probably have use for more maps and drawings than any other phase of the industry. These maps are always on different scales, for there is no uniformity in the drafting of them and everyone who has the supervision of the map-making in a company has his own ideas on how it should be done. Frequently, it is necessary to change maps from one scale to another; this may lead to inaccuracy when ordinary methods are used

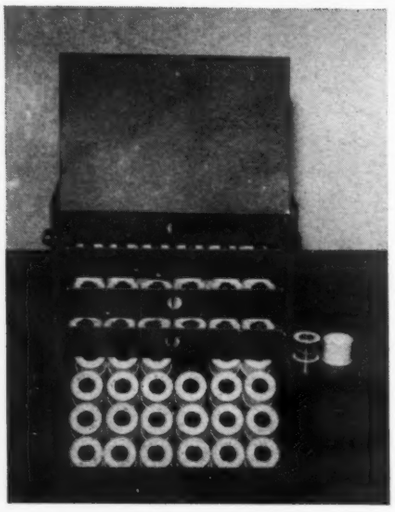
In the writer's experience, he has found it very practical to photograph on 35-millimeter film those maps on which it is necessary to change the scale, and, by projection methods, to eliminate distortions in the original prints and save much drafting time besides. This is particularly true when dealing with irregular tracts and numerous property lines.

Quarter section maps on a scale of 100 ft. to the inch have been photographed individually at a reduction of approximately 28 diameters and the negative developed. A projection board consisting of a slide for a projector, a mirror at 45 deg., and a plate glass table above the mirror is used in this projection method (see accompanying illustration). By inserting the film in the projector and sliding the projector backward and forward, the size of the map desired is obtained. Minor adjustments of the mirror remove any distortion in the image that might be in the original print. As the exact distances are known, an outline is drawn of the boundary lines of each section on 100 percent rag paper, and the film projected so that the corners of each quarter section coincide with the outline that has been drafted. The adoption of this method permits the accurate tracing of property lines, well logs and any other data that might be desired in the drafted outline.

This method of reproducing maps



Front view of reader, open. Note microfilm on reels on top of reader



Cabinet for filing spools of microfilm

has been practiced in the engineering problem of reservoir study of the Wilcox zone in the Oklahoma City field, Oklahoma. Specific application of microfilming has also been advantageous in attacking this problem, a resumé of which will give some idea of the many benefits of this type of recording in the solution of numerous intricate problems involved in obtaining records.

Inasmuch as records to be obtained included geological and production records of various oil company offices, it was first necessary to locate the material desired or to know where it could be procured. Arrangements were then made with these companies to photograph all records in their files that were essential to a study of the particular problem. At such time as it was convenient for the company, a man was sent with portable equipment, the material withdrawn from the files and photographed in their offices. After photographing each roll of film it was developed overnight and ready for use the following day. So far, only negatives have been used in this work, as it is felt that additional cost of positive prints is not warranted at this time.

The above manner of handling the work has served several quite specific purposes. A wealth of material, much more complete than could have been obtained otherwise, is on file for study. As most of the information is of a confidential nature to each company involved, it should be kept even more confidential when copied on film for study outside of the company. The use of film helps in many ways to solve this particular problem, because by having virtually bound volumes after photographing any particular records, it is impossible to lose individual sheets and for any outsider to refer to any particular copied information without the use of a reading machine.

Much of the detailed geological information obtained at the time wells were completed in the Wilcox zone was on well-log strips that were prepared at the time geological examination was made of the well cuttings. There was no need to be particularly interested in the comparison of one strip against another, but it was essential to obtain all the detail on the strips without having to resort to actual copying of the logs. Permission was obtained from some of the companies to photograph their well-log strips. Thus was provided a photographic copy of all the information desired, much of which has been transferred to a well record form.

So far, all copy work on well-log strips has been on positive film, which gives only gradations of black and white. It should be pointed out here that the application of colored film to copy work of this sort gives excellent results, if actual colors are desired. In the event that comparison between several well-log strips or cross-section work were to be done with the strips, photographing in color to any scale desired and then making either film strips or film slides would probably be best and be very satisfactory.

The beginning of all records necessary for petroleum engineering and other work in oil companies is in field offices. The current practice is to make such copies of these records as are necessary for the various departments in the company. Good field records are essential for efficient operation and it is important that original records be preserved in such a manner that they are readily available for any particular use desired. Microfilming not only accomplishes this, but, in addition, permits the transfer of numerous field records to headquarter offices with a convenience, accuracy, and economy that is not possible by any other method.

Work of the writer within the last year has occasioned frequent solicitation of various types of court records, which not only had numerous exhibits but very lengthy testimonies having either a historical or legal value. A complete copy of numerous cases has been obtained from various sources by microfilming methods at a cost far below that which would have been necessary had any other method been employed. The work was not only speedily done, but in many cases records could not be moved from the office in which they were filed. As a result, these records were photographed in minimum time, at a great saving and without removal of the original records.

Among the important considerations with regard to the application of microfilming are:

1. The preservation of original oil-field operating and other records that facilitate greatly petroleum engineering field studies.
2. Current records can be filed and made much more accessible than by the methods generally used.
3. The space saved in the preservation of obsolete records not only is a great economical saving but insures against loss of valuable records.
4. Portable equipment has been developed that makes it possible to take the equipment to the work for the purpose of obtaining necessary data on any problem. This compares with the present method of the application of photography by photostating, which can only be used when the work can be taken to the equipment and which involves a cost that is prohibitive when copying is voluminous.

Reader, which projects image on microfilm to more than full-page size, in use for study of data

P 422.91

Drilling-Rig Layout for Water Locations In the Gulf Coast

Engineering study of design results in elimination of 25 piles by using steel structural members—cost is reduced because steel may be moved from one location to another

By I. W. ALCORN
Chief Petroleum Engineer
Gulf Coast Producing Division, Pure Oil Company

IN RECENT YEARS much has been done to facilitate drilling operations in water areas, particularly with respect to the foundations supporting the rig. The art has advanced from crude mats and piling foundations to more improved mats and piling layouts and on through the development of the well-known drilling barge. Indeed, the drilling barge has undergone tremendous development, and it has increased correspondingly in cost.

It is unnecessary to dwell at great length on the conventional drilling barge other than to say that the average setup for either a steam or Diesel-electric rig would cost about as follows:

Drilling barge proper . .	$30,000
Power or boiler barge . .	20,000
Mounting equipment, piping, etc.	20,000
Royalty	15,000
Total	$85,000

This total figure is probably slightly below the average.

Straight piling structures supporting the entire rig would cost from $10,000 to $20,000, so that it is easy to see how a program involving eight or ten wells would about amortize the barge investment.

As opposed to the two above solutions, it is suggested that an economical solution to the problem is a compromise of the two methods. The method proposed and now in use has been employed in the drilling and completion of one well, and involves the following:

Mounting on a piling foundation the derrick, drawworks, engine, rotary table, and shale shakers. An engineering and economic study of this phase of the problem has indicated that, instead of a conventional 56-pile layout with much bracing, a structure could be designed with 31 piles and the total elimination of all knee, cross, or horizontal bracing (Fig. 1). A layout of this type has alone eliminated much unnecessary expense in labor and material. Instead of the conventional timber caps, 24-in., 100-lb. steel beams were used. This design was arrived at by considering a 150,000-lb. rotary load plus 100 percent impact or total of 300,000 lb. and assuming that the 4 piles under the rotary table were out of the picture, as it is possible for them to be due to washout of the hole. All piling is driven and rated for a 30,000-lb. load-bearing value. Inasmuch as all the piling are interconnected by bolted steel beams, it is obvious that all the piling are going to be doing some useful work all the time. In many structures in the past, the corners were separate from the rotary table and the engine not directly tied into the derrick structure. With this particular rig a 12 by 12 vertical engine is used with the hoist and a 7¾ by 7 vertical engine rotary drive is used. The structure has proved extremely rigid and satisfies all requirements. It will be noted that the shale shaker is set on a cantilever, by extending the two 24-in. beams supporting the rotary table.

I. W. ALCORN

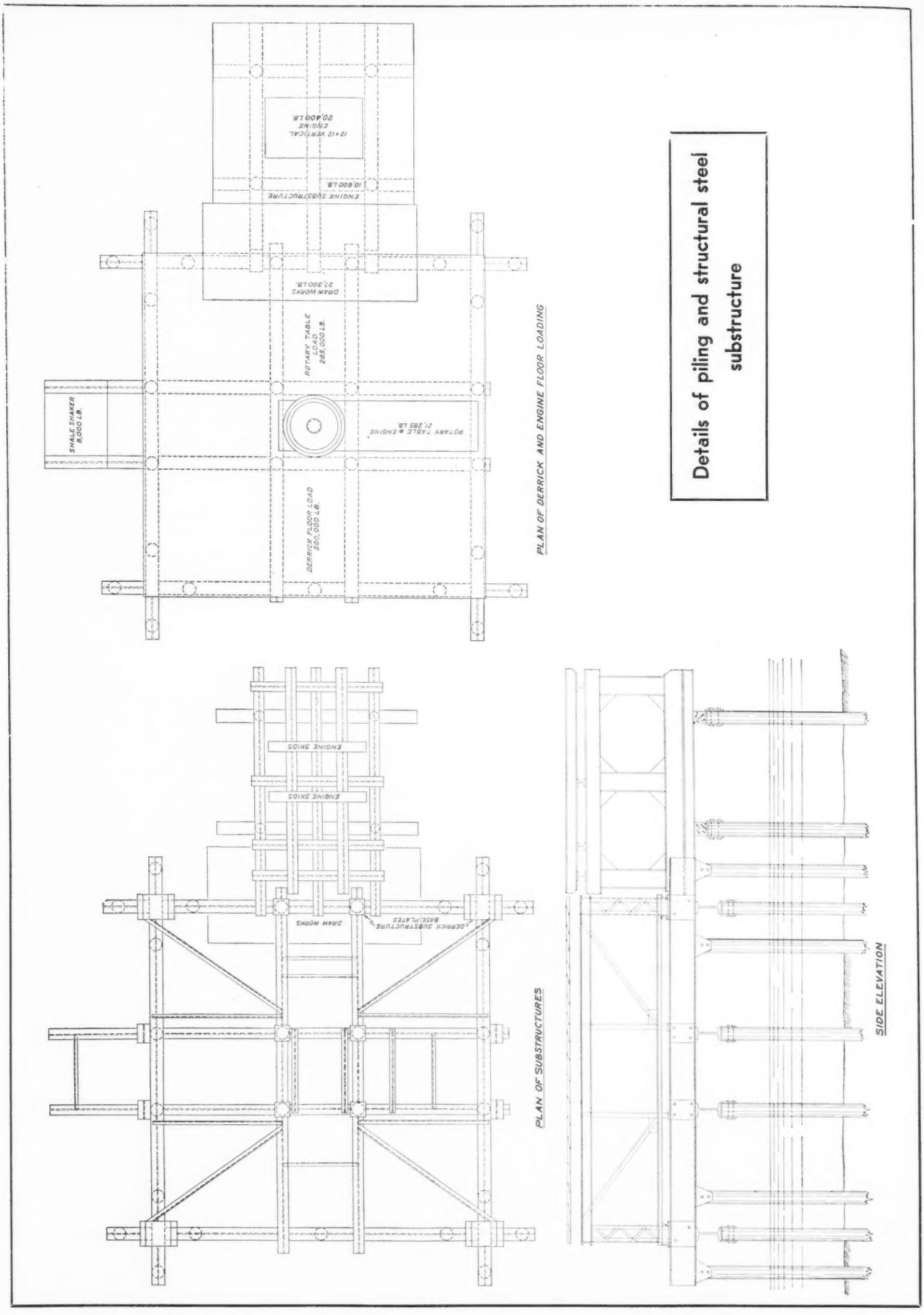
was born September 5, 1899, at Marietta, Ohio—Has received degrees in mining engineering from the Missouri School of Mines, Rolla, Missouri, and Massachusetts Institute of Technology —Began career in oil industry with Independent Oil and Gas Company —Later served on staffs of Smith Separator Company and Oil Well Supply Company—Employed by Pure Oil Company in November, 1935—Elected first president Houston Technical Club, organized in 1938.

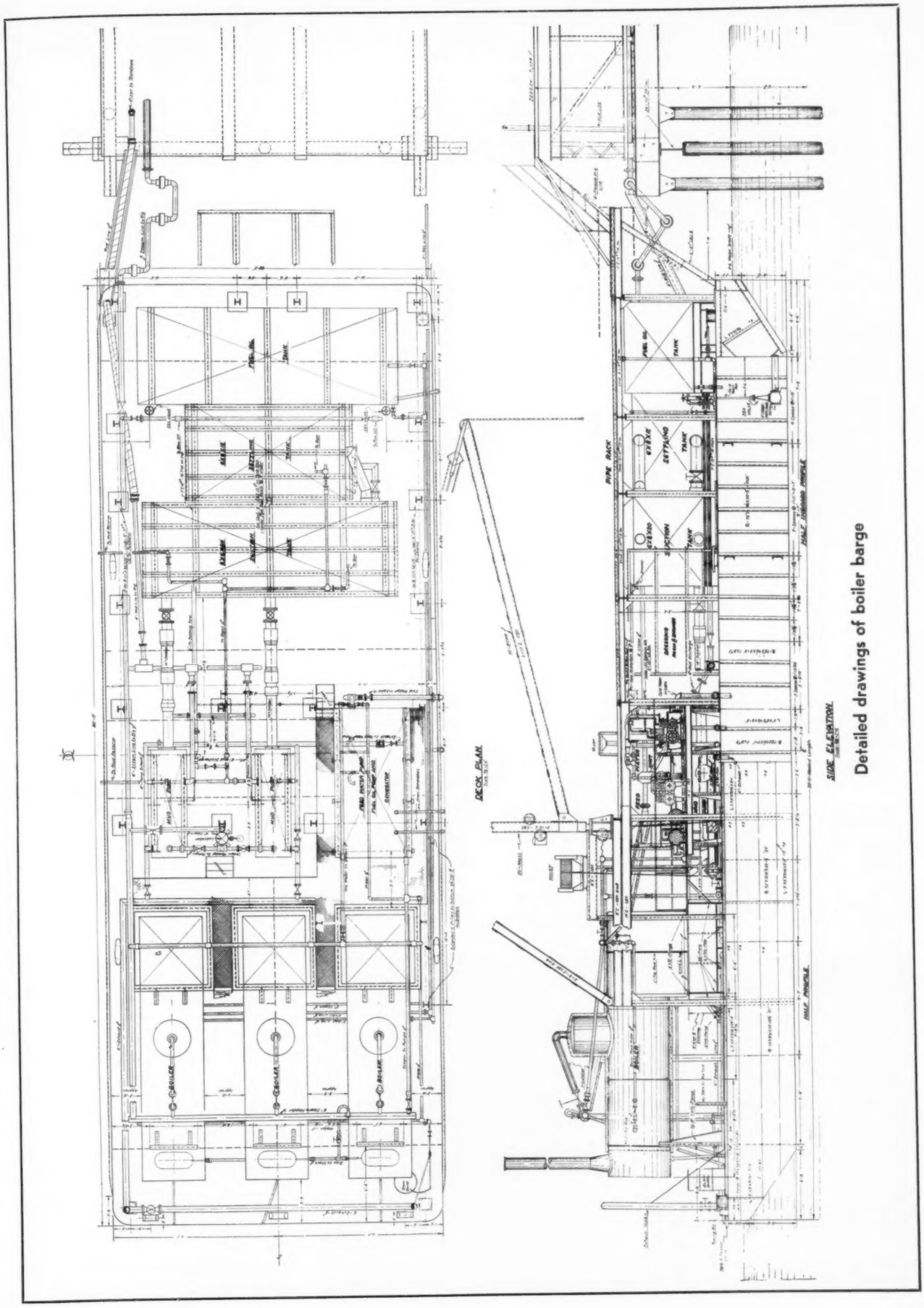
The barge has proved an interesting problem. The barge proper was a 28-ft. by 80-ft. by 6-ft. steel barge on which formerly was mounted a house boat. The latter was skidded off and the barge converted into a support for the boilers (Fig. 2). On this small space is mounted three 250-lb. boilers; two 18-in. direct-acting pumps; boiler-feed unit and generators; a suction mud tank; a settling mud tank, and a 175-bbl. fuel-oil tank. On the top of the tanks and above part of pumps was erected a pipe rack on which was mounted a 10-ton derrick mast with a 35-ft. boom, operated with a small steam engine and small hoist.

Although this would not be considered a large Gulf Coast rig, it is aptly suited for the particular area in which it is operating, and with only a slightly larger barge, the larger rigs and derricks could be mounted in similar fashion.

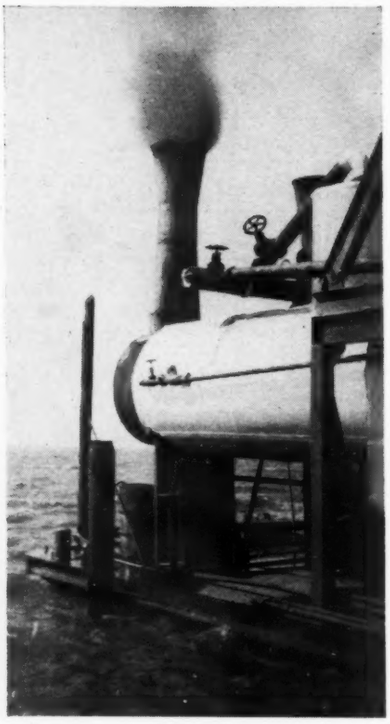
There is nothing particularly unusual in the mounting of the equipment. The boilers are mounted 3 ft. above the deck; a false bottom 6 in. above the deck provides air circulation or serves as a water pan if the deck becomes too hot. Thus, a height of 2½ ft. is provided for the duck's nest burner setting.

Anticipating that there might be considerable movement of the floating


Details of piling and structural steel substructure
PLAN OF DERRICK AND ENGINE FLOOR LOADING
PLAN OF SUBSTRUCTURES
SIDE ELEVATION
ENGINE SKIDS
DRAW WORKS
DERRICK SUBSTRUCTURE BASE PLATES



Detailed drawings of boiler barge



The boilers and other power equipment are mounted on a submersible barge

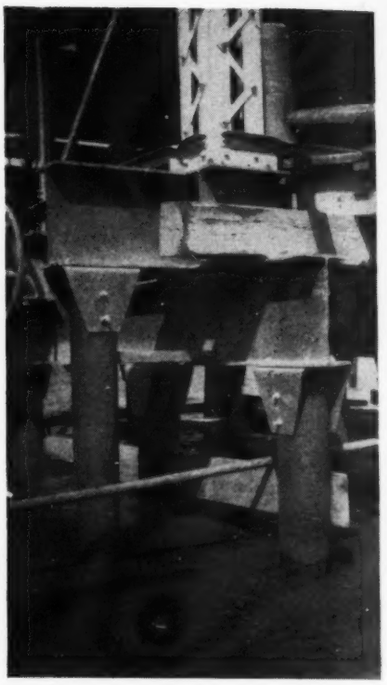
barge, it was stipulated that a rotary hose should be used in the mud line. As a steam line, a flexible steel rotary hose was used; to make it applicable, however, to steam service (250-lb. pressure and 400°F. temperature), it was necessary to work over the joints, providing retaining rings, and packing the joints with buckshot—a method that has proved surprisingly satisfactory.

After placing the barge in operation it was interesting to note that only a very slight movement was perceptible, even during fairly rough weather. This fact has prompted the consideration of the relationship of mass, depth of water, submergence or draft of barge, and length of barge as affecting the stability. With this thought in mind, it is believed that the entire setup lends itself particularly well to much deeper water and possibly to tideland operations in some instances.

The most interesting feature of this combination of piling, steel-beamed derrick and engine platform, and floating power barge and pipe rack, is the cost. The cost elements may be listed as follows:

Cost of driving piling and placing steel beams . .	$ 352
Cost of dismantling derrick and substructure and towing barge to present location	178
Cost of erecting derrick and substructures, building ramp and floor, and setting shale shakers	495
	$1,025
Cost of creosoted piling .	828
Cost of steel beams (fabricated) complete with galvanized bolts . . .	1,350
	$3,203

Considering that the steel will be used over and over again, its cost would be prorated at $350 per well so that the above figure would be reduced by $1000. The actual cost is, therefore, $2203 for the derrick and engine structure, including the expense of both dismantling and erecting the derrick and substructure. It should be pointed out that all this cost is not necessarily charged entirely against drilling, as only pilings are driven that will have continued use, in the event the well is a producer, during the producing life.

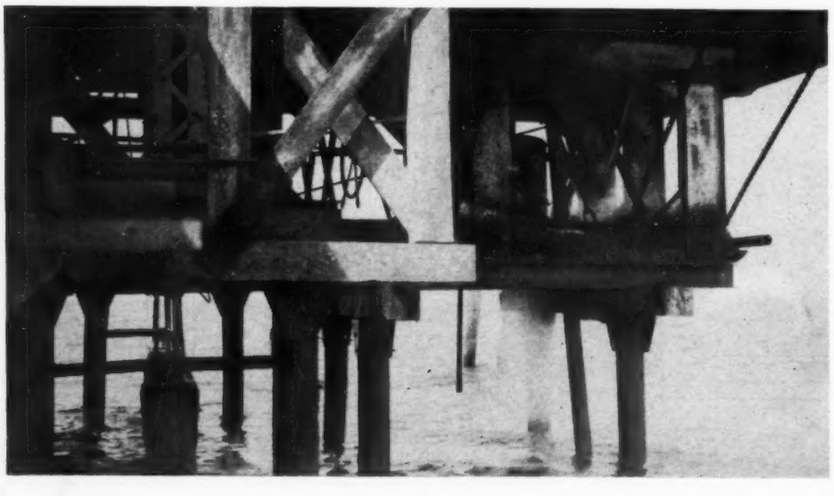


The four piles at each corner of the derrick are loaded equally

Cost of Barge

Cost of barge proper . .	$6,500
Cost of mounting all equipment, building pipe rack, derrick mast, cleaning, painting, and dry-docking, etc., except piping . .	5,200
Additional labor, piping, etc.	800
Total cost of barge less drilling equipment and tanks	$12,500

In this particular operation, two similar derricks and substructures are available and a duplicate set of steel beams is being obtained. With this a location ready with derrick erected is provided in advance so that on completion of one well it is only necessary to move engine, drawworks, rotary table, and shale shakers, which would not require more than one day before drilling is started on the next location.



View of substructure supporting drilling engine

Stove-piping a section of line between Richards and Conroe stations

A PETROLEUM ENGINEER EXCLUSIVE FEATURE

By

FRANK H. LOVE

Managing Editor

Latest Methods and Equipment Used in Pipe-Line Reconditioning Work

Screwed line laid in 1912 between Corsicana and Beaumont, Texas, cleaned, spot welded, and coated—Collars eliminated and joints welded to reduce leakage

CONTINUING the policy of maintaining its system at maximum operating efficiency, the Magnolia Pipe Line Company has just completed the reconditioning of another section of its 8-in. Corsicana-Beaumont line, laid in 1912. During the last several years the company has made systematic repairs to its lines whenever needed. This latest project involves the taking-up, cleaning, repairing, coating, wrapping, and re-laying of one of four parallel lines. The sections being repaired are between Brown station, Leon County, and Iola station, Madison County, and between Richards station, Grimes County, and Conroe station, Montgomery County. Three of the lines are 8-in. and one is a 10-in. One feature of the work was the removal of all screwed collars and the electric welding of all joints to eliminate collar leaks.

The work was performed by two contractors. The section between Brown and Iola stations was reconditioned by the O. C. Whitaker Company and that between Richards and Conroe stations by Mitchell-Stewart Corporation. The former section was reconditioned partly in a central yard, the latter entirely on the line.

The working procedure between the Richards and Conroe stations consisted first of stripping the pipe. This was done with a ditching machine equipped with a stripping shoe that plowed beside the pipe as it was uncovered leaving it in condition to be easily lifted from the ditch by tractors and winches and placed on skids.

In cleaning the pipe four cleaning

Coating and wrapping pipe in one operation

Cleaning pipe in a central yard

cleaning machine, equipped half with knives and half with brushes, was run. After this second cleaning the screwed collars were cut and the pipe ends beveled with an acetylene torch in a single operation. Magnolia inspectors then graded the pipe, the first class stock being left on the right-of-way to be relaid and the second class pipe trucked to a yard and stacked for possible use later on gravity lines where high pressures are not essential. The second class pipe thus removed from the line was replaced by new.

The stove-pipe method of welding was employed and for this purpose two electric-welding machines were used for tacking and seven for making the bell-hole welds. Three beads were run. An additional welding machine was used later for spot welding.

Before proceeding with cleaning operations the pipe was again washed with kerosine and gasoline in the same manner as that described, after which the third cleaning machine was run. This machine was equipped half with knives and half with brushes, the same as the second machine.

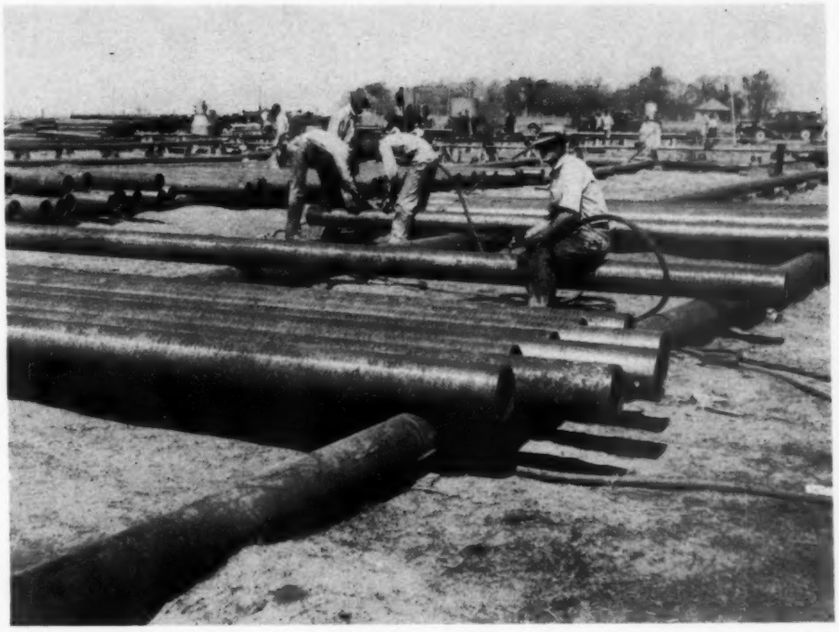
At this stage of the work the surface of the pipe was clean but corrosion still clung to some of the deeper pits. To remove this the pipe was mechanically "pecked" by eight to ten air hammers before being spot welded. All pits measuring as much as 150 mils were spot welded. These welds were ground level with the pipe by emery wheels operated from an air compressor, to prevent puncturing of coating and wrapper.

Burning corrosion from pits with an acetylene torch

machines were passed over it. The head of the first machine was equipped entirely with knives to remove the old coating, dirt, and the worst part of the corrosion. The next step was to wash the pipe with kerosine and gasoline, brushed on by hand. The workman applying the kerosine was followed at a distance of about 1000 ft. by the one applying the gasoline, giving sufficient time for the first to dry before being followed by the second application. Rust and scale remaining on the pipe thus were loosened before the second

In re-laying the pipe all joints were electric welded

Air hammers were used for "pecking" to remove corrosion from shallow pits



The fourth and final cleaning machine was run after this operation, the head of which was equipped entirely with brushes. Before being approved by the inspectors for priming, however, four to eight workmen employing "hand pecking" tools removed rust from the shallower pits.

Priming was by hand, being "ragged on." Application of the hot coating and asbestos felt and kraft paper wrappers was with the popular type machine that performs all three functions in one operation. The unit is self-propelled, being driven by a gasoline engine. The machine, as it rides the pipe, is maintained upright by means of a balance pole handled by one workman. The engine that powers the machine also drives the wrapping arms and operates the pump that circulates coating material from the drip pan back into the hopper from which it flows over the pipe. The hopper at the top of the unit receives the hot coating and a valve at its base is the medium for regulating the flow. Overflow coating is caught in a drip pan beneath the equipment and is pumped back into the hopper. Wrapping immediately followed the coating application, skids were removed, and the pipe lowered-in. A skid was left every 300 ft., the ditch being filled between the loops by an angle dozer. The skids were pulled and the loops backfilled before the sun hit them the next day, this work being performed between 3 and 4 o'clock in the morning when the pipe was fully contracted. The final act was for the "dress-

Traveling-type cleaning machines putting the finishing touches on the pipe before it was coated and wrapped

up" gang to clean the right-of-way and be certain all fences were left in the proper condition.

The line was relaid in new ditch, close to the old one but not nearer than 6 ft. to any of the paralleling lines.

The pipe taken up between the Brown and Iola stations was hauled to a yard centrally situated between the two points and there cleaned. This part of the line was uncovered by hand, 50

(Continued on Page 86)

Uncovering the line with a ditching machine

See Our Exhibit

INTERNATIONAL PETROLEUM EXPOSITION TULSA MAY. 18-25

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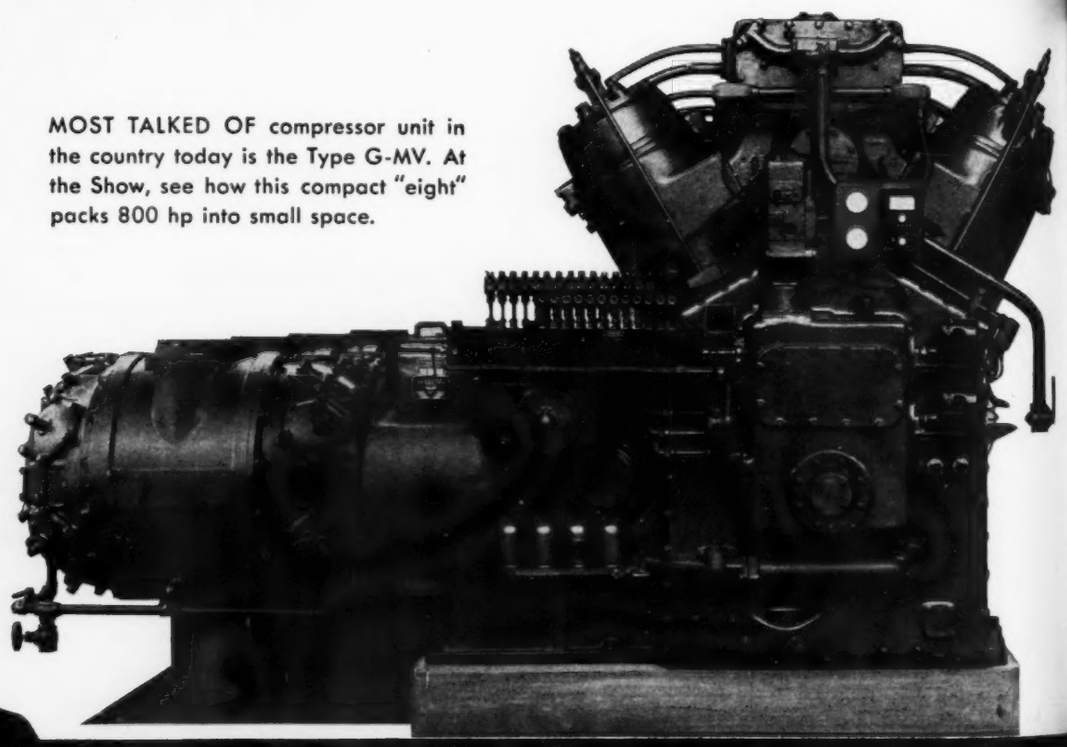
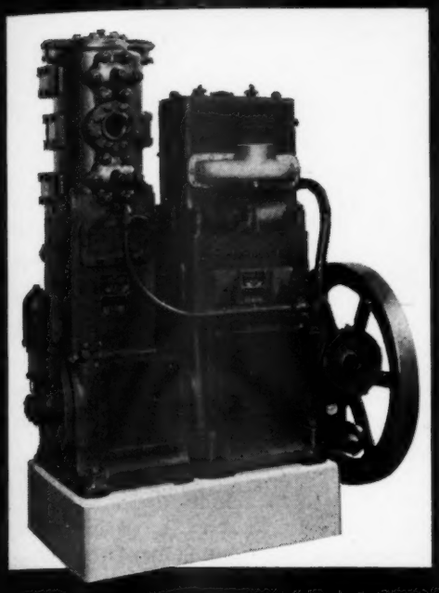


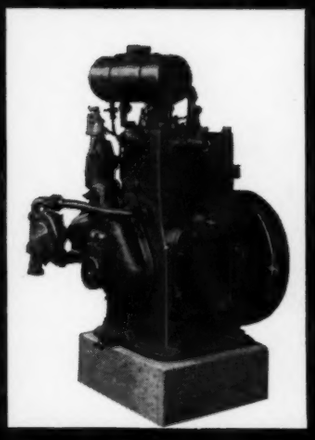
COOPER-

THE COOPER-BESSEMER CORPORATION

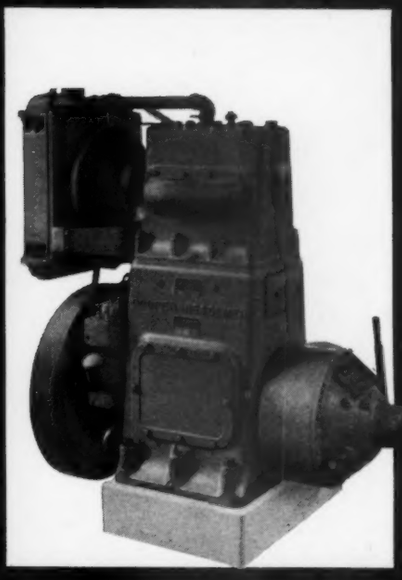
Mount Vernon, Ohio — PLANTS — Grove City, Pennsylvania



ANOTHER GREAT space-saver is the Type G-MS vertical compressor unit . . . 40 to 50 hp . . . and another compressor cylinder can be added for two-stage operation.

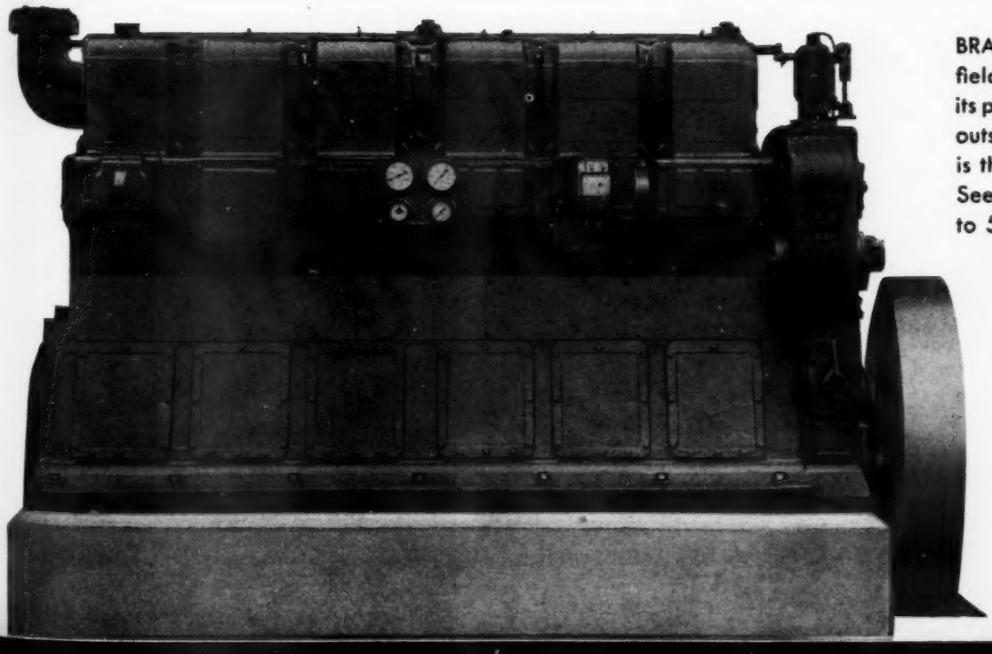


STARTING UNIT rated 6 hp. Furnishes 250 pounds' air pressure. Gas or gasoline fueled.

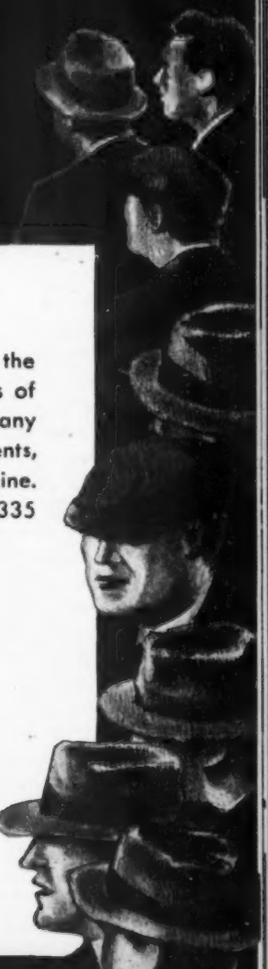


TYPE G-SC pumping engine . . . "built to outlast the field" . . . Rated 25 to 40 hp.

WE HOPE YOU can come to the Show . . . but if you miss it, check up on these "all-star" performers through our nearest representative.



BRAND NEW, with all the field-proved features of its predecessors, plus many outstanding improvements, is the Type JS gas engine. See the "six," rated 335 to 520 hp.



BESSEMER

25 W. 43rd St., New York City Investment Bldg., Washington, D. C. 640 E. 61st St., Los Angeles, Calif. 201 E. 1st St., Tulsa, Okla.
631 Spring St., Shreveport, La. Magnolia Bldg., Dallas, Texas M & M Bldg., Houston, Texas
Box 1856, Pampa, Texas Box 455, Greggton, Texas

Tacking a joint held in place by a clamping device

(Continued from Page 83)

workmen stripping 2 to 3 miles per day. Collars were split with acetylene torches and the pipe was then lifted from the ditch by side-boom tractors, wedges first being placed between the exposed pipe ends to prevent damage.

At the central yard two cleaning machines were set-up approximately 30 ft. apart. The first machine, equipped entirely with knives, removed the old coating. The second was equipped partly with knives and partly with brushes. As the pipe progressed through the machines the ends were steadied by workmen equipped with bars having a hooked end to prevent the pipe from turning. Each joint of pipe was joined to the succeeding joint by a 7⅜-in. plug that fit inside the 8-in. pipe. This resulted in a faster movement through the machines and provided a solid joint that obviated possible damage to the machine head. Another particular of this work was to maintain a continuous flow of water over the pipe to keep the coating cold and thus more easily removable. The water used for this purpose was trucked to the yard and emptied into a large tank from where it gravitated through a rubber hose to the first cleaning machine.

As the pipe left the second cleaning machine it was rolled onto two racks and beveled, the collars having been knocked off upon arrival at the yard and before entering the first cleaning machine. After the pipe was beveled it was graded into classes A, B, C, and junk. The A pipe consisted of stock good enough to relay in the line without spot welding. The grades B and C pipe required varying degrees of spot welding and were placed on what were termed "pit racks". Here rust was burned from the pits with acetylene torches before being spot welded. Grinding-down of welds, mechanical pecking, buffing, and the application of kerosine preceded the return of the pipe to the right-of-way.

At the yard a manifold was installed to which was connected two air compressors. Operated from this manifold were 12 air hammers and two buffers. The purpose of this installation was principally that of convenience, eliminating as it did the need for long and unwieldly lengths of hose that otherwise would be required to connect the various equipment with the compressors. Also installed were two 135-lb. generators to provide acetylene for the bevelers.

Upon being strung the pipe was welded into the line by the firing-line method, the next steps then being the running of two cleaning machines over the line while it was still on skids above the ditch. One machine was equipped with one set of knives, the rest of the head being brushes; the other machine was equipped entirely with brushes. From the first of these machines gasoline flowed from the fuel tank onto the pipe ahead of the cleaning head to aid in the removal of the kerosine applied at the central yard as well as any remaining coating material. The pipe on this section of the line was coated and wrapped in the same manner as described for the section from Richards to Conroe stations.

The condition of the pipe when removed from the ground and the thorough manner in which it has been reconditioned lead Magnolia officials to believe that it may give as many as 30 more years of efficient service.

Pipe-cutting machines that hold blowpipe at a fixed angle were used to bevel the ends of the pipe on both sides of the salvaged collar

"MAKE MINE STARCOR-

W 2407

FIELD: East Texas
TYPE OF JOB: Squeeze, through shot holes
DEPTH OF WELL: 3638 ft. Retainer set: 3617 ft.
MAX. TEMP.: 145° F.
SLURRY WEIGHT: 16.4 lb. per gal.
CEMENT USED: 'Starcor', 150 sacks
MIXING TIME: 15 min.
PUMPING-DOWN TIME: 25 min.
REMARKS: 38 sacks of 'Starcor' pumped out through 20 shot holes with maximum pressure 3700 lb. A salt-water well converted into one making pipe-line oil.

S 3921

FIELD: Eureka
TYPE OF JOB: Casing job, 6-5/8"
DEPTH OF WELL: 7693 ft.
MAX. TEMP.: 190° F.
SLURRY WEIGHT: 16.5 lb. per gal.
CEMENT USED: 'Starcor', 800 sacks
PUMPING-DOWN TIME: 1 hr., 30 min.
MAX. PUMP. PRESSURE: 2000 lb.
REMARKS: No unusual angles -- typical of 'Starcor' performance, day in, day out.

"FOR GREATER LENGTH AND EASE OF PUMPABILITY"

IT'S the follow-through that counts—whether you're taking a cut at curve-ball pitching, swinging your driver from the inside out on the tee—or cementing a casing in a hole with temperatures near the "bilin' p'int." That's why these days Oil Men say, "Make Mine 'Starcor.'" Because 'Starcor' sure has got the follow-through Oil Men need—the greater length and ease of pumpability at high temperatures that spells success, even when the going's toughest.

Use 'Starcor'* for deep, hot holes and extra sulphate resistance. Use 'Incor'* for wells of moderate depth—earlier drill-out, wells on production quicker.

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USE 'STARCOR'
for deep wells, greater length and ease of pumpability at high temperatures, and extra sulphate resistance.

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for wells of moderate depth—earlier drill-out, wells on production quicker.

P 234.
P 721.7

The Technology of Refining Processes

Article 4

ALKYLATION, HYDROGENATION, and RELATED PROCESSES

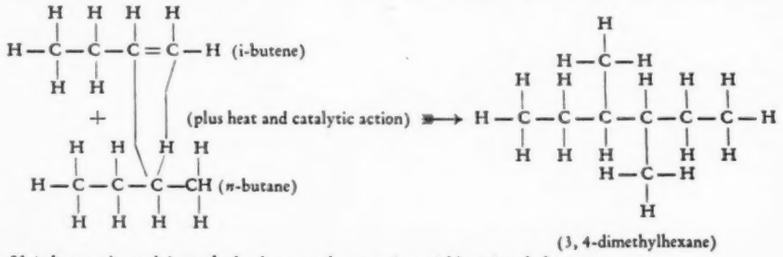
By

ARCH L. FOSTER

The Lubri-Zol Corporation, Cleveland, Ohio

ALKYLATION of paraffinic hydrocarbons by olefins, although first reported in the technical literature in 1925 (Ipatieff et al, *Bull. Soc. Chim.* 37, p. 157, 1925) has developed so rapidly in the refining industry that now, second to polymerization, it is the most important new reaction that can be applied commercially. Some years ago the process of making technical *iso*octane by polymerization and then hydrogenation of the polymer in the presence of sulphuric acid catalyst was developed, and ten or more units were built in this country and abroad to operate the process, particularly for making aviation fuels of high octane number. With the development of the alkylation process it is understood that several, if not all, these units will be converted to the new method, as it is considerably cheaper than the two-step polymerization-hydrogenation process.

Alkylation is the process of adding olefins to paraffins, or preferably to *iso*-paraffins, which in one step forms a new, larger and saturated molecule chiefly of the *iso*paraffinic type, high in octane number and with a satisfactory vapor pressure, both properties depending on the structure of the reacting hydrocarbons and on the conditions employed in the process. The mechanism is apparently the breaking of the double bond of the olefin, the transfer of a hydrogen from the paraffin to one of the valences so freed in the olefin, and a combination of the two molecules by the one free valence remaining in each, as follows:



NOTE: If *iso*butane is used instead of *n*butane, the reaction yields trimethyl pentanes.

A number of different *iso*octanes may be formed by this reaction, the positions of the double bond and of the two carbons that are united to form the long chain deciding the structure of the resulting molecule. The different *iso*octanes have somewhat different knock ratings, but all are much higher in anti-knock properties than the straight paraffin, *n*octane. Control of conditions of alkylation will produce differences in the major reaction.

As will be shown later the operating conditions required for the alkylation of *iso*paraffins by olefins with sulphuric acid are mild and the principal expense in the preparation of *iso*octanes, etc., by this method is the cost of concentrating the reacting components before bringing them into reaction.

ARCH L. FOSTER

is widely known in refining and automotive technical circles—His present work as sales engineer for The Lubri-Zol Corporation is concerned principally with lubricants and lubricant-treating methods—Previous experience since 1922, when he graduated from the University of Texas, was with the Gulf Refining Company, the U. S. Bureau of Mines, and the *National Petroleum News*.

Before outlining details of alkylation processes, it is enlightening to consider the possibilities of charge stocks for these purposes, and the value and usefulness of the products. Gard et al, *(Proc. Calif. Nat. Gaso. Assn.*, Nov. 17, 1939) state that 1,800,000 bbl. of alkylation products can be made annually from the hydrocarbons available in California alone, which would have an unleaded octane number of about 91 A.S.T.M. (about 95 Army Method), or 100 Army octane number with 1.5 cc. of lead. Combined with selected straight-run naphthas and using 3 cc. of lead this would produce about 3,000,000 bbl. per year of 100 octane number aviation fuels. As the amount that could be manufactured from all the available gases in the U. S. is probably three times this quantity, it is obvious that our potential production is greatly in excess of present demands. Gard estimates that 400,000 bbl. per year is the present "local" demand for these superfuels, that is, those having higher than 86 octane number ratings. These fuels are selling at 15-16 cents per gal. with a relatively narrow margin of profit for the refiner at that price, so that in the writer's opinion production of high-octane-number blending naphthas for the improvement of motor fuel is impracticable. The cost of an alkylation unit is estimated at $2500 per bbl. of product per day, or about eight times the cost of a cracking unit for the same capacity. Other indications, however, such as the recent strong increase in octane numbers of regular and premium grade motor fuels, point to the likelihood that some of the excess alkylation and polymerization capacity may be utilized to maintain a higher octane level in housebrand gasolines. The trend of engine compression ratios upward supports this idea.

The potential advantages of extremely high-octane-number aviation fuels is enormous, Heron says *(National Petroleum News*, Nov. 17, 1937, p. R-307). Although commercial airlines are not using 100-octane-number fuels as a regular practice, it is likely that

in the near future they will be supplied with engines demanding this type of fuel. Demand for maximum take-off power is the factor that will bring this about, he says. Fuels of 100 octane number give 17 to 30 percent more take-off power than those of 92 octane number. *Iso*octane plus 3 cc. of lead gives 55 percent more power than *iso*-octane alone, the Army has found. Fuels of more than 100 octane number show as much as 60 percent power increase over *iso*octane in engines designed to use these superfuels, or 250 percent as much power as is obtained with 70-octane-number fuel.

Difference in fuel consumption, operating on 92- and 100-octane-number fuels, is about 19 percent less for the higher rated fuel, Klein of the Army Air Corps reports *(Trans. Soc. Auto. Engrs., 39,* 2-1936). Specific fuel consumption—consumption per b. hp-hr. —for 87 octane number has been reduced to as low as 0.44 lb.; with 100-octane-number fuel in suitable engines this can be reduced to about 0.38 lb., Heron points out. One of the disadvantages of the lower quality fuel is that, with the heavier planes of today, longer and longer runways are necessary to take-off safely. With the higher output engine-fuel combination using 100-octane-number fuel the size of airports can be kept smaller; the initial investment in airports, which must be near large cities where ground space is expensive, is already excessive, and its proportion of the cost of operating airlines is large.

Airlines can earn as much as 11.4 cents per octane number per gal. by using 100-octane-number fuels as compared to 87-octane-number fuel, it is estimated by Bass *(Aircraft Eng. of G. Britain,* Jan., 1937). This is equivalent to $1.48 per gal. more value in the better fuel, based on payload revenues. From these and other data it is obvious that the operating and revenue value of better fuels, rated in terms of earning power, is high, and that trends toward the use of better fuels is inevitable, when and as engines designed to obtain the best from them are employed by the airlines. The advantage of such fuels to the military services are obvious.

Alkylation With Sulphuric Acid

Alkylation by the sulphuric acid process usually employs *iso*-butane as the paraffin, chiefly for the reason that this hydrocarbon has a high volatility, and finds less use in motor fuel than normal butane. The *iso*butane is introduced into the acid, in concentrations of from 2½ to 5 times the concentration of the olefin used, in a reactor into which the olefin is pumped. Acid concentration is maintained at 96-100 percent acid, is withdrawn when its strength falls appreciably below that value, and make-up acid is added to maintain it at the optimum concentration for the best yields. Contact times between the olefin and the *iso*paraffin-acid mixture vary from 5 to 20 minutes or more. Temperatures of the reacting materials may be varied widely, but for butanes and butenes the range is usually from 32° to 50°F. for good yields and long acid life. The reaction products are removed from the reactor, acid is separated and returned to the reaction zone, the combined products are scrubbed with caustic, debutanized, and the *iso*butane is recycled to the reactors. Operations are so managed that little if any olefin comes through the system unreacted.

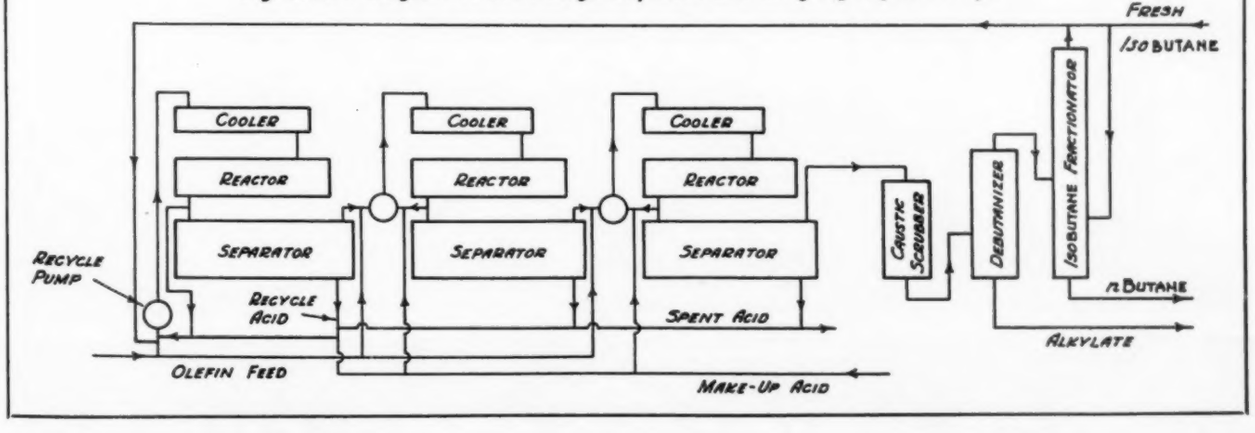
Many factors have been found to have important effects on the operation (Peterkin et al., *A.P.I. Proceedings,* Nov. 17, 1939). Acid cannot be allowed to go below 88-90 percent concentration without seriously affecting the output. The mol ratio of *iso*-paraffin to olefin must be maintained high, otherwise the olefin combines to form alkyl sulphates with the acid, and yields are reduced excessively. The ratio of *iso*pentanes to olefin require a higher ratio than that for C_4 stocks, or higher than 5:1, because of the lower reactivity of the heavier pentanes. Gard et al., *(Proc. Calif. Gaso. Assn.,* Nov. 17, 1939) show that when treating a mixture of paraffins containing *iso*butane, the yields increase rapidly as the *iso*butane percentage increases to 35 percent. He also states that for butenes the best reaction temperature is 30°F. For propene, 80°F. reaction temperature is needed to give the best results. When a 1:1 ratio of the two is used, the required temperature is about 55°F. Other ratios, in mixed-olefin feed stocks will require a temperature between these limits, depending on the proportions of each product present.

Below about 80°F. propene dissolves in the acid to form the alkyl sulphate, thus reducing the effective acid strength. At 80°F., reaction with the *iso*paraffin is rapid, but acid life is shortened because of side reactions that increase with temperature. The ratio of acid to hydrocarbon in the reactor is usually 1:1, but may be as high as 2:1, depending on the nature of the charge gases. Olefins should be present in the total hydrocarbon feed to the extent of 8-14 percent. If a large quantity of normal paraffin is present, which is said not to enter the reaction appreciably, the *iso*paraffin-olefin ratio may be increased above 5:1 for the best results. The reacting mixture must be agitated effectively; for this purpose, a method of recycling by a pump through a system of baffles is used.

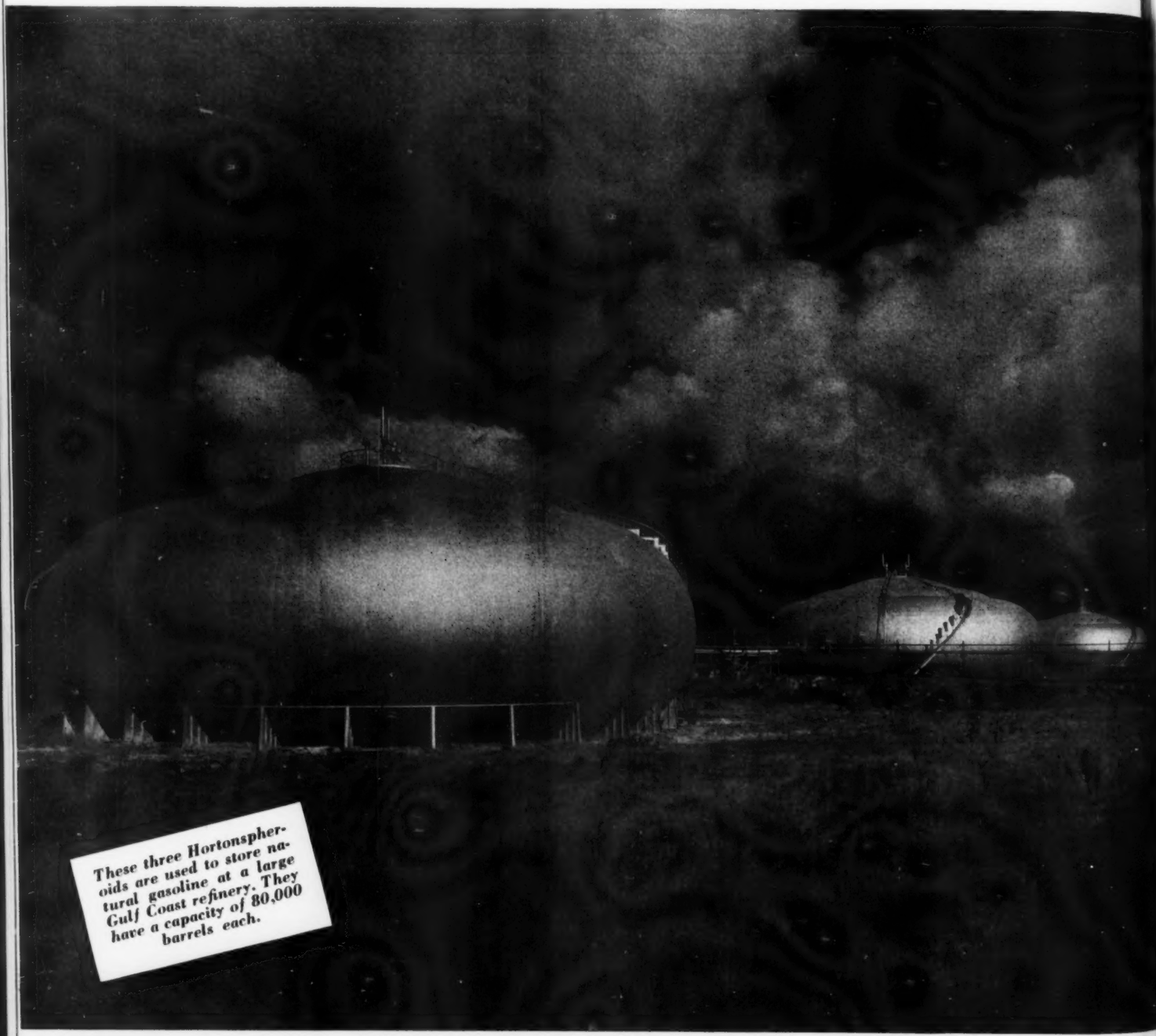
When alkylating with mixed hydrocarbons, the major portion of the reaction products are formed by direct combination of the typical hydrocarbons involved. That is, when propene and *iso*butane react, most of the prod-

(Continued on Page 94)

Fig. 1. Flow diagram of three-stage alkylation unit using H_2SO_4 as catalyst



MODERN TANKS



These three Hortonspheroids are used to store natural gasoline at a large Gulf Coast refinery. They have a capacity of 80,000 barrels each.

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The modern solution to the problem of evaporation losses is simple, direct and of proven effectiveness. For any given oil storage requirement, you can get specially developed tanks or roofs which greatly reduce or completely eliminate evaporation —that common source of product loss or deterioration. How to select the best suited units—how to use them—and how much they can save, are engineering problems worthy of your most careful attention. The various types of tanks and evaporation saving equipment include the following:

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THE WIGGINS BALLOON ROOF makes the breather roof principle both practical and profitable for smaller standing storage tanks and for tanks that are not always kept filled.

THE WIGGINS BALLOON is a larger unit designed to act as a central gas holder in vapor-saving systems serving groups of tanks through inter-connected gas-tight piping.

THE HORTONSPHERE is a modern pressure storage container available in capacities of 1,000 to 12,500 bbls. or more, for pressures of from 25 to 250 lbs. per sq. in.

THE HORTONSPHEROID is widely used in capacities up to 30,000-bbls. as a pressure storage unit for pressures up to 25 lbs. per sq. in. Also in larger sizes for handling high test motor fuels at pressures from 2½ to 5 pounds per sq. in.

We will be glad to give you complete information about any or all of these products. Please address our nearest office.

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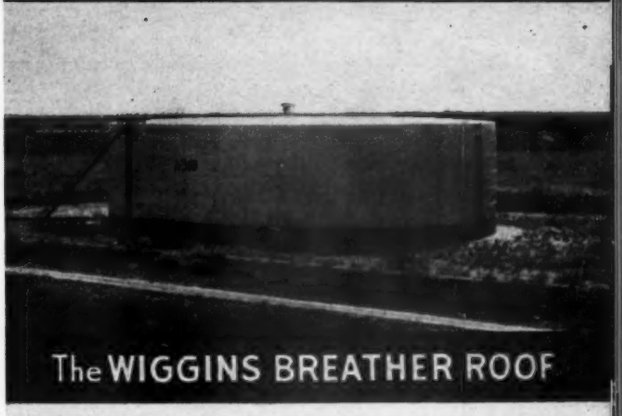

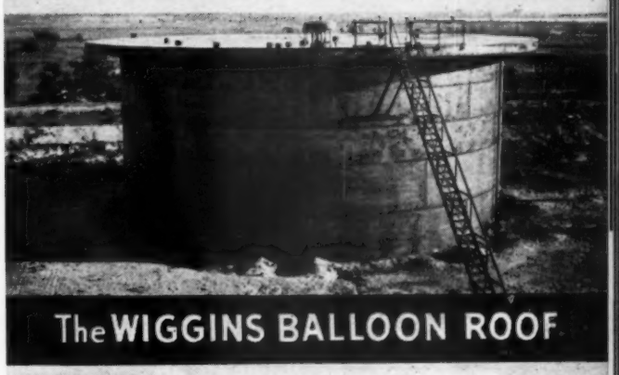

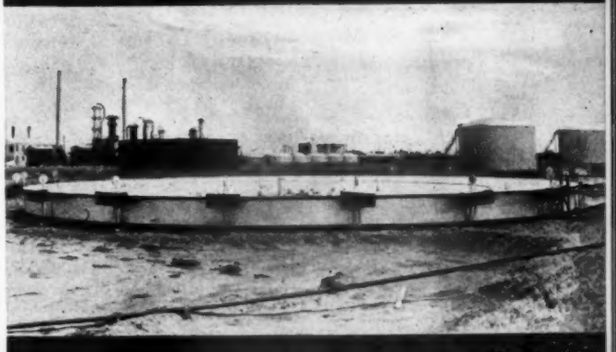

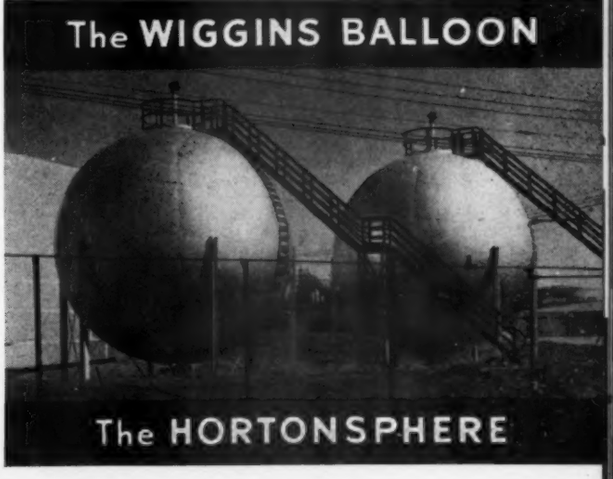

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(Continued from Page 91)

uct is composed of *iso*heptanes; when butene and *iso*butane react, *iso*octanes are formed chiefly, and so on.

Properties of H_2SO_4-Alkylated Products

One outstanding advantage of alkylated fuels as compared to *iso*octanes, etc., from polymerization-hydrogenation reactions is that the vapor pressures of the alkylated products are generally higher than that of *iso*octane, and therefore are more nearly finished aviation fuels. From 85 to 90 percent of the reaction products boil below 300°F. If pentanes and butanes are added, or included in the reaction charge and removed with the fuel during stabilization, any necessary vapor pressure or volatility characteristics may be obtained without the addition of other blending materials. Alkylation fuels from almost any source are practically sulphur-free, and the lead susceptibility is considered higher than that of typical refinery gasolines. These facts, combined with the fact that blending values are higher than from any other source, make the alkylated product the best in its field, in the opinion of experienced engineers.

Alkylation of various stocks shows interesting data. With *iso*paraffin-olefin ratios of from 5:1 to 8:1, a C_3 fraction from cracked gases yielded 138 percent of the olefin used; a C_4 fraction gives 158-180 percent yields based on the olefin used, and a 70°-210°F. cracked gasoline fraction used to alkylate *iso*butane gave a 113 percent yield based on the olefin present in the fraction. The A.S.T.M. octane numbers of these products were, respectively, 88, 91.5, 92.5, and 79. Vapor pressure ranged from 3.5 to 7.5 lb. Reid.

Alkylation plants with combined capacities of some 12,000 bbl. of alkylate per day were operating or under construction at the beginning of 1940. Assuming a 300-day operating year, these plants could produce 3,600,000 bbl. of alkylated fuel per annum, of which doubtless 3,000,000 bbl. would be premium aviation grade, producing 100 octane number fuel with a small lead addition. The fuel is almost completely saturated, highly *iso*paraffinic, and has practically no gum. A typical product shows 85 A.S.T.M. octane number, which gives 100 Army octane number with 3 cc. of lead, 7-lb. vapor pressure, 1 mg. gum, acid heat of only 2, and 308°F. endpoint.

Acid "consumption" is one of the large items in the manufacture of alkylated aviation fuels. The acid is not consumed in the normal sense but is diluted with hydrocarbons, and may be recovered by water dilution to 50 percent strength or other desirable ratio, to cause separation of the hydrocarbons, after which the acid-water solution may be reconcentrated and reused.

Manufacture of Neohexane

Neohexane is prepared in the Phillips process by the alkylation of *iso*butane with ethylene. The process is thermal; ethane is dehydrogenated at low pressure and high temperature (See Article 3, and is absorbed in a part of the *iso*butane charge. This mixture is introduced at different points in a pipe coil through which more *iso*butane is pumped; the whole mixture is maintained at 950°F. Pressures of 3000-5000 lb. per sq. in. are employed in the coil, which serves as a reactor, and unreacted products are separated from the alkylate by fractionation, for recycle. The ratio of paraffin to olefin is kept high to prevent formation of tars; product is yellow in color and has a gravity of about 73°F. A.P.I. and A.S.T.M. octane number of 82-83. Blended with the heptanes and octanes produced as side reactions and with 3 cc. of lead, this neohexane product shows 100 Army octane number, a fuel containing no *iso*octane.

Neohexane is formed by the reaction:

$$\begin{matrix} & & C & & & & C & \\ C-C & + & C & = & C & \rightarrow & C-C & -C-C \\ & & C & & & & C & \end{matrix}$$

olefin combines with the tertiary carbon of the *iso*paraffin by breaking the double bond, the hydrogen from the paraffin migrating to satisfy the free bond in the ethylene radical. Neohexane boils at 121.5°F., has a vapor pressure of 9.5 lb., and an A.S.T.M. octane number of 94. When treated with 3 cc. of lead, its anti-knock rating equals that of pure *iso*octane. Its lead susceptibility is much higher than that of an *iso*octane-heptane blend of 94 octane number, 3 cc. producing the same effect that 6.5 cc. does on the blend containing normal heptane.

This high lead susceptibility gives a great advantage in the use of neohexane in preparing fuels of higher than 100 octane number. By comparison, 6 cc. of lead are required to raise *iso*octane to 118.7 octane number (Oberfell and Frey, *A.P.I. Proc.*, Nov. 1939). The same rating can be obtained with neohexane and 4.5 cc. of lead. A 50-50 blend of the two hydrocarbons yields the same rating with 4.9 cc., showing that the lead susceptibility of the hexane is retained in blends, and can be used to advantage both for volatility and anti-knock properties in tomorrow's superfuels.

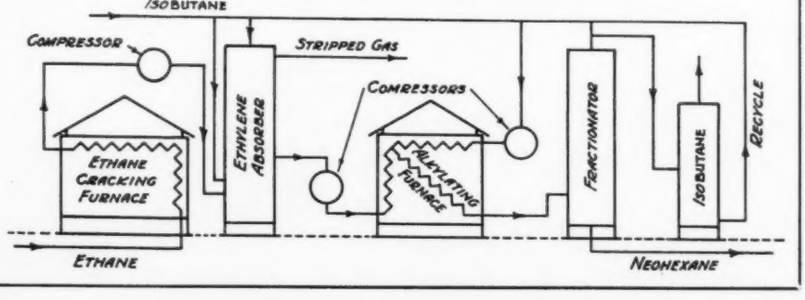
Of the five possible hexanes only two are high in anti-knock rating, neohexane and 2,3-dimethylbutane, the latter having about 95 A.S.T.M. rating. Of the other three, normal hexane rates at 34, 2-methylpentane at 73, and 3-methylpentane at 74.5.

The manufacture of neohexane on a large scale is dependent on a plentiful supply of *iso*butane. Ethane in practically unlimited quantities is available wherever natural gas is found; considerable quantities of ethylene are found in refinery cracked gases, and in a large refinery the quantity may easily be large enough to warrant installation of a unit, particularly if the advances in aviatio nengines and 100-octane-number fuel requirements in the next few years are as large as may reasonably be expected. With large production of *iso*octane both by polymerization-hydrogenation and by alkylation of *iso*butane, and with neohexane and/or 2,3-dimethylbutane, its isomer, to supply high octane number, high volatility, and high lead susceptibility, future supplies of 100-120 octane number fuels are entirely assured.

Hydrogenation

Hydrogenation as it was developed by the Standard-I. G. interests in this country, although being a successful process technically speaking, as announced several years ago has not been generally adopted chiefly because of its high installation and operating costs. It involved addition of hydrogen to heavier petroleum stocks, under ex-

Fig. 2. Thermal dehydrogenation of ethane and thermal alkylation of *iso*butane with ethylene



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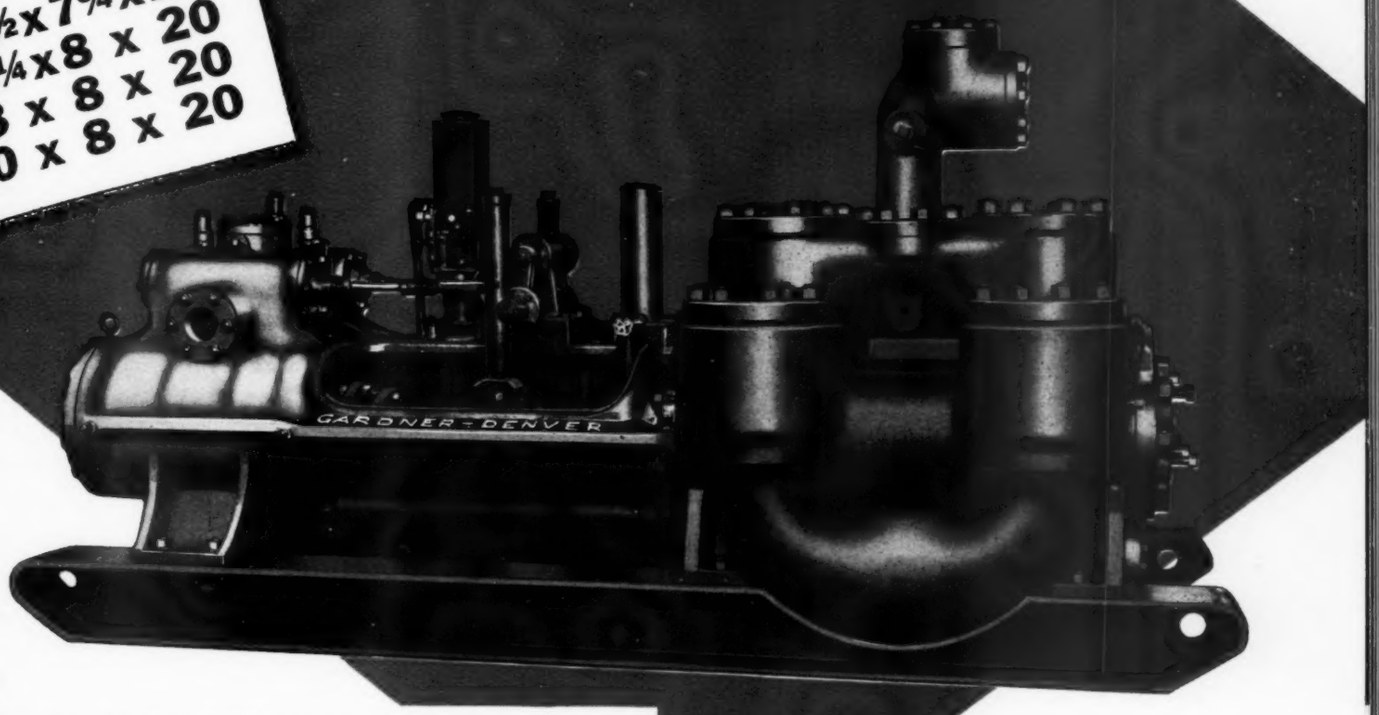

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tremely high pressures and temperatures in the presence of a catalyst, and showed ultimate yields of more than 100 percent, but at present is used chiefly to produce special naphthas and other products of high market value and limited demand.

Hydrogenation by catalytic means has made it possible to use the polymerization process, already described in an earlier article, for the production of saturated *iso*octane and other *iso*paraffins suitable for aviation fuels from light refinery and natural gases. Butenes from refinery cracked gases, or formed by cracking or catalytically dehydrogenating natural gas butanes are polymerized as described in a previous article. In the latter process, the charge stock is concentrated to obtain a maximum yield of butenes with only small amounts of other olefins. The *iso*octene so formed is hydrogenated to saturation by either thermal or catalytic methods, the latter being the commercially adopted process.

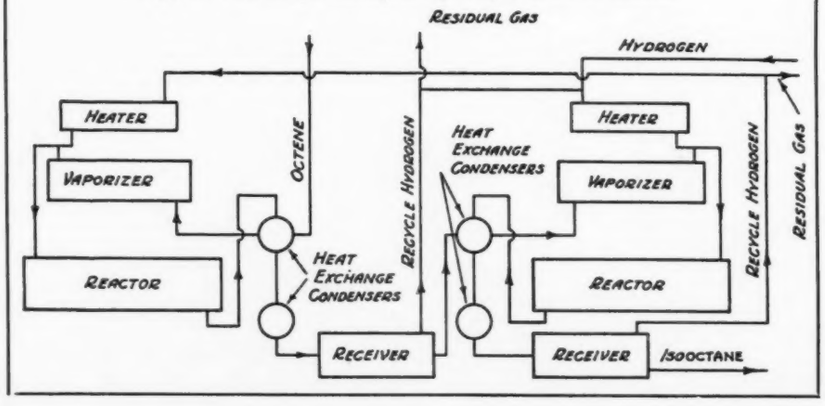
Shell Development Company hydrogenates *iso*octene or other olefins by the use of a catalyst composed of reduced nickel carried on a porcelain base. The olefin charge is introduced into the reactors at temperatures as high as 390°F. and pressures of 60 lb. gauge or lower. The reaction is exothermic. Higher pressures have been found to be deleterious to the catalyst, because they compress the reaction mixture and produce overheating of the catalyst with damage to both catalyst activity and *iso*paraffin yields. Polymerized *iso*butene and *n*butenes are used generally in this process, producing a mixture of octanes with octane numbers only slightly below that of pure 2,2,4-trimethylpentane, which is the isomer usually referred to as *iso*octane, the octane number of which is, by definition, 100.

Because the cost of hydrogen, prior to the discovery of the catalytic method of dehydrogenating paraffins, is a large item in the total cost of operation, two-stage reactors are employed, the residual hydrogen from the first being led to the second to react with the incoming olefin in that stage. Although the cost of hydrogen obtained by catalytic means is reported to be lower than by other methods, it is still high, and reaction efficiencies of 90-95 percent for hydrogen are obtained to make the process economical.

This nickel catalyst is very susceptible to sulphur poisoning, and elaborate precautions are used to remove practically every trace of sulphur from the reacting gases. Carbon monoxide forms nickel carbonyl with the catalyst, which can be broken down by reactivation with air at elevated temperatures, in place. Sulphur is absorbed by the catalyst almost quantitatively from the gases, and when its activity is reduced below a practicable value the catalyst must be removed from the reactors for complete regeneration.

The catalyst retains its affinity for sulphur long after its reactivity as a hydrogenation promoter is too low for practical purposes. When it becomes too inactive for hydrogenation, therefore, the spent catalyst is placed in a contactor ahead of the reactors, in which it removes the sulphur from the incoming olefins, thus protecting the fresher catalyst in the reactors from any but very slow contamination by the sulphur. *Iso*octanes so produced contain less than 0.0001 percent sulphur. The polymerized octenes are treated prior to this catalytic desulphurizing step to reduce sulphur to about 0.002 percent; the spent catalyst reduces this amount further to 0.0005 percent, the small remaining amount being taken up by the fresh catalyst. Because this small amount of sulphur deactivates the catalyst very slowly, as much as 1000 gal. of olefins per lb. of nickel may be hydrogenated.

Fig. 3. Two-stage catalytic hydrogenation of olefins



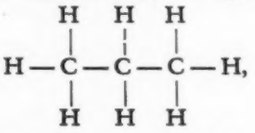
A 10-15 percent excess of hydrogen over the theoretical is employed in this process to improve the rate and efficiency of hydrogenation. In single-stage operations the octane-hydrogen mixture is passed through the catalyst, the exit gases are compressed and cooled to recover the hydrogenated reaction product, and the recovered gas is recycled. As much as 80 percent recycle gas is used in some plant operations. This method increases the hydrogen-olefin ratio by nearly 25 percent, saving 5 to 10 percent of hydrogen.

For the improvement of motor and aviation fuels of the future no process mentioned in these pages is amiss. Each has certain advantages in the product it makes that render that product suitable for use in various finished fuels. The combination of these products may be made to produce almost any type of fuel desired for commercial or military use in more exacting engines than any now made.

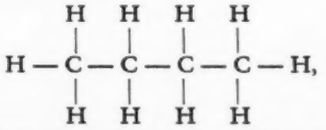
Isomerization and Aromatization

Isomerization is an interesting chemical reaction, but the reason for its mention here is the present commercial and technical importance of the reaction as a means of preparation of high-value fuels, or to prepare intermediates for other processes that are employed to manufacture those fuels. Obviously the principle can be applied widely in syntheses of all types of products and in making intermediates available in large commercial quantities for the chemical industry.

Isomerization is, briefly, the changing of molecular structure from one form to a more desired form, without changing the percentage composition or the nature of the elements included in the product. The reaction can be used only on those products that can have more than one structure form; for example, propane, C_3H_8,



cannot be arranged in any other form or configuration except as cyclopropane, C_3H_6; therefore it can have no isomer. Butane,



called normal butane or *n*butane because the carbon atoms are arranged in a single straight line or "chain," can exist as an isomer with the same number of C and H atoms, as *iso*butane or i-butane,

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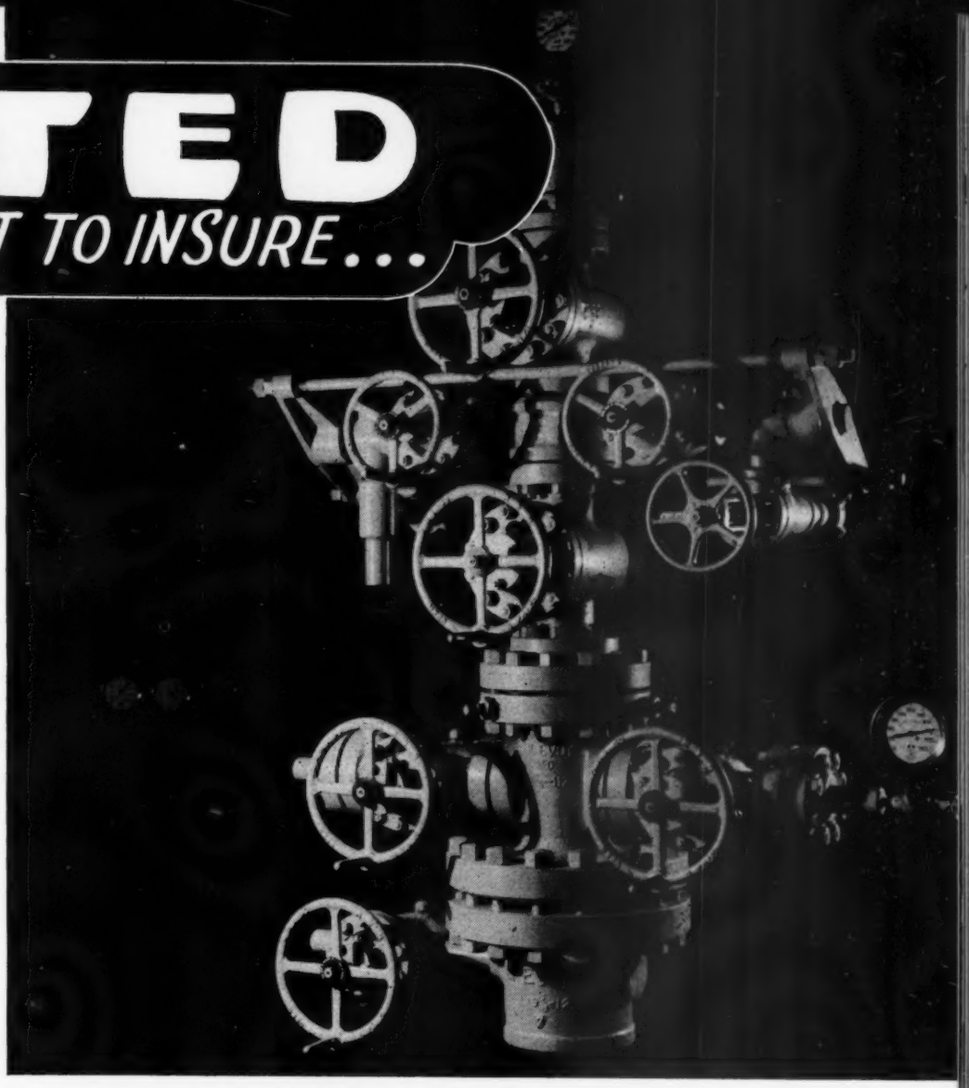

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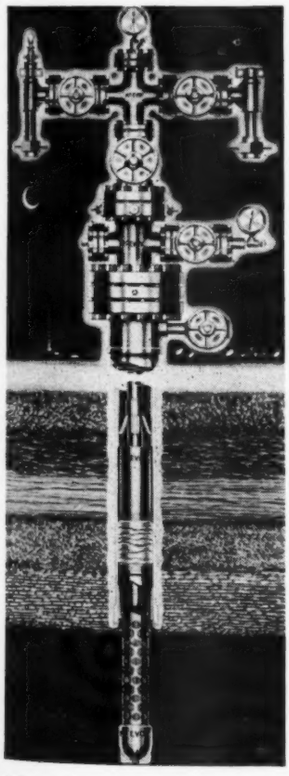

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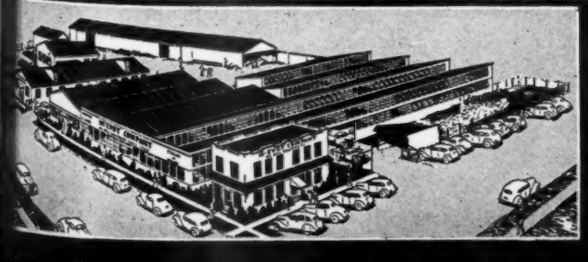

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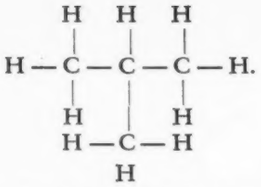


In the normal hydrocarbon no carbon is attached to more than two other carbon atoms; in isomeric forms one or more carbon atoms may have three, or even four carbon atoms attached. As a general principle the more complex a hydrocarbon molecule is, the higher its anti-knock rating. This statement for practical purposes should be applied only to hydrocarbons that boil in the normal distillation range of motor and aviation fuels. Consequently the effort of fuel technologists is to produce the more complex molecules. Reforming of straight-run gasolines effects this change of structure in considerable degree; reforming probably improves octane rating more by the dehydrogenation of paraffins to form olefins and by the recombination of cracked hydrocarbon radicals into more complex molecules of the same general boiling range than it does by isomerization of the normal hydrocarbons.

Preparation of higher anti-knock rating fuels directly by isomerization doubtless will be, in the future, one of the important applications of the reaction. At present, and so far as the refining technologist is immediately concerned, the production of *iso*paraffins from the much more common normal paraffins found in natural and refinery light distillates and gases is the most important application. *n*Butane reacts in the alkylation process, described in Article 3 *(The Petroleum Engineer,* March, 1940, page 36) only slightly if at all, and not to any degree that can be considered commercially practicable under known methods. Conversion of *n*butane to *iso*butane, however, provides the most important and most expensive intermediate for this more and more widely applied process. Methods that make the supply of available *iso*butane or *iso*pentane greater, therefore, are of primary importance to the refining, automotive, and aviation industries.

Back in 1933, *n*hexane and *n*heptane were converted to their isomers by heating at their boiling points for several hours with 30 percent aluminum chloride (Berichte 66, 1892). Later Ipatieff and Grosse *(Ind. Eng. Chem.* 28, 461, 1936), employed anhydrous aluminum chloride with HCl as a promoter, to isomerize normal butane, hexane, and heptane, obtaining 25-30 percent isomerization, with various percentages of other higher- and lower-boiling products. Montgomery, McAteer, and Franke (*Proc. Am. Chem. Soc.*, April, 1939), found that anhydrous aluminum bromide is a more effective catalyst for isomerization reactions. They found that isomerization reactions are reversible, equilibrium being reached at about 75-80 percent *iso*butane conversion.

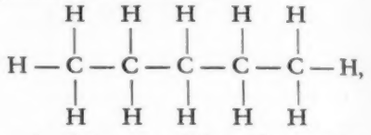
Egloff, Komarewsky, and Hulla (*Proc. Am. Chem. Soc.*, April, 1939), find that *n*butane is changed to *iso*butane in 66.5 percent yield with 12 hr. heating at 300°F. and 450-lb. pressure in the presence of 16 percent aluminum chloride and 1.6 percent HCl (French Pat. No. 823,595, Jan. 22, 1938). These investigators corroborated the findings of Montgomery et al that equilibrium is established at about 80 percent isomerization of the normal hydrocarbon. The same writers converted *n*pentane to its isomers in the presence of aluminum chloride on activated carbon, with 1 percent HCl dissolved in the pentane, using 450-lb. pressure and 390°F. temperature. Conversion was 27 percent per pass; total yield of recycling was 80 percent.

Isomerization of *n*hexane in 55 percent yield is accomplished with aluminum chloride and HCl in 3 hr. at atmospheric pressure and 160°F. Six percent of *iso*butane is also formed, along with 15-20 percent of other lower- and higher-boiling hydrocarbons. *Iso*butane is formed as a side reaction of the isomerization of other hydrocarbons more often apparently than any other individual molecule.

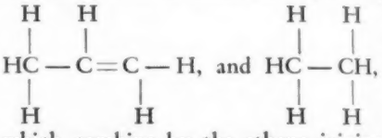
Normal octane may be converted to *iso*octane in 23 percent yield by heating with the same catalysts for 3 hours at 1050-lb. pressure and 410°F., Egloff and collaborators found. A number of catalysts have been found efficacious as isomerization catalysts, among them being molybdenum sulphide, MoS_3, zinc chloride, platinum, charcoal, and nickel-alumina.

Aromatization, or cyclization of paraffin and olefin materials can be produced thermally; for example, heating acetylene or methane produces benzene. Ketones such as acetone may be converted to benzene or its homologues, toluene, xylene, etc., by the action of sulphuric acid. Taylor and Turkevich (*Proc. Am. Chem. Soc.*, April, 1939) found that heptane may be converted quantitatively to toluene, $C_6H_5CH_3$, by heating at 875°F. with chromic oxide gel made by the slow precipitation to oxide from chromic nitrate solutions with ammonia. Other catalysts are thoria on pumice, on alumina gel, or activated alumina. The chromic oxide catalyst is poisoned by water or water-forming gases such as oxygen or olefins that may decompose during reaction. The catalyst may be regenerated by heating with oxygen or air at the temperature employed in the aromatization reaction.

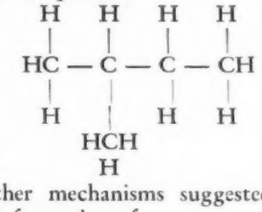
The mechanism of the isomerization reaction has been variously interpreted. Egloff et al suggest that in isomerizing *n*pentane the molecule,



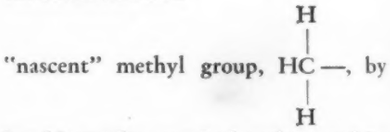
may break into an olefin and a paraffin,



which combine by the ethane joining the middle carbon of the propene to form *iso*pentane:

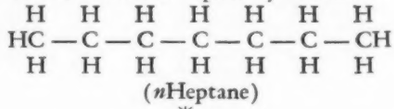


Other mechanisms suggested include the formation of a

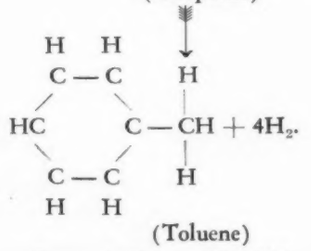


breaking off a terminal carbon and its attached hydrogen atoms from the chain, and a recombination with the chain by reaction between the methyl group and a secondary or "inside" carbon atom to form the isomer.

Aromatization of a normal paraffin indicates dehydrogenation of the carbons until only one hydrogen remains attached to each carbon, the chain is closed, and there is formed the peculiar unsaturated cyclic molecule, which is termed the "benzene ring." Thus, in the formation of toluene from *n*heptane the reaction is possibly as follows:



(*n*Heptane)



(Toluene)

EDITOR'S NOTE: The fifth article in this series takes up catalysis in the refining industry.

P 538.21

Analysis of Delayed Drilling Program in Water-Flooding Project

Data covering an 8-year operating period on a Bradford, Pennsylvania, oil lease studied to determine the relative merits of various plans of exploitation

By PAUL M. PHILLIPPI

Olean Petroleum Company, Eastern Division, Olean, New York

IT IS assumed that most individuals interested in the oil industry are conversant with or have a knowledge of secondary recovery methods by water-flooding as practiced in the Bradford, Pennsylvania, and Allegany, New York, oil fields. Much has been written on this subject so that the engineering principles involved are generally understood.

In simple terms, the five-spot system of water-flooding, which is the most extensively utilized method, consists of drilling water intake wells at positions corresponding to the corners of a square with an oil well in the center. This arrangement may be continued to the boundary of the property so that on the average, a given input well pushes oil to four producing wells and a given producing well drains the oil from four input wells. Water under applied pressure is forced into the oil sand through the water intake wells and fluid is pumped from the oil wells.

Common practice, particularly in the early days of water-flooding, was to drill the oil wells first and follow up at a later date with the water wells. With this system the initial production is small, but it gradually increases until the effect of the water is maximum and the peak in oil production is reached. This is illustrated by the typical "no delay" production curves shown in Fig. 1.

The usual length of time required for the oil wells to reach their peak production after water has been turned into the wells varies from 6 to 18 months. The time required for the injected water to penetrate the effective distance before movement of the oil is apparent in the oil well is dependent entirely upon conditions, several of which may be controlled by the operator.

PAUL M. PHILLIPPI

received a bachelor's degree in geology from the University of Nebraska in 1929 — From November, 1929, to May, 1931, was with the Petroleum Engineering Laboratory at Bradford, Pennsylvania, and from May, 1931, to February, 1932, was instrument man with the State of Nebraska Highway Department — He then became a laboratory technician for Torrey, Fralich and Simmons, geologists and petroleum engineers, Bradford, serving with them until August, 1932, when he became a geologist for the Olean Petroleum Company, Eastern Division, Olean, New York—Is in charge of the core analysis laboratory for that company.

Three of these controllable conditions are:

(1) Well spacing
(2) Applied pressure
(3) Shooting

Other factors may present difficulties unless properly provided for and are due to the physical properties of the sand body itself. They are:

(1) Permeability
(2) Heterogeneity in permeability of the strata comprising the producing horizon
(3) Degree of saturation
(4) Porosity.

The producing sands of the Bradford and adjoining pools are believed to be uniform. Since the introduction of detailed core analysis, however, it has been found in certain areas throughout the field that there is a great variance in permeability and other physical characteristics of the sand. Operating under the method previously described, a great amount of bypassing occurred. Such a condition shortens the economic life of a flood because the strata of high permeability, which have been watered-out first, continue to take a major portion of the injected water without producing any oil. Not only is it costly to treat and inject the water, but it must also be lifted with the oil. Even though the water is penetrating the sections of lower permeability, the water-oil ratios may be unfavorable for continued economic operation.

In an effort to overcome this condition and in order to attain a more uniform flooding front, delayed drilling was first attempted. It was contended that if the intake wells were drilled first and water under a constant pressure forced into the sand, the water would penetrate the looser streaks first and then having no outlet, the tighter portions of the sand would take the water and become penetrated in a like manner. After an interval of time, usually 6 to 18 months, the oil well in the center would be drilled and peak production encountered at once. (See production curves for typical delayed well in Fig. 1.)

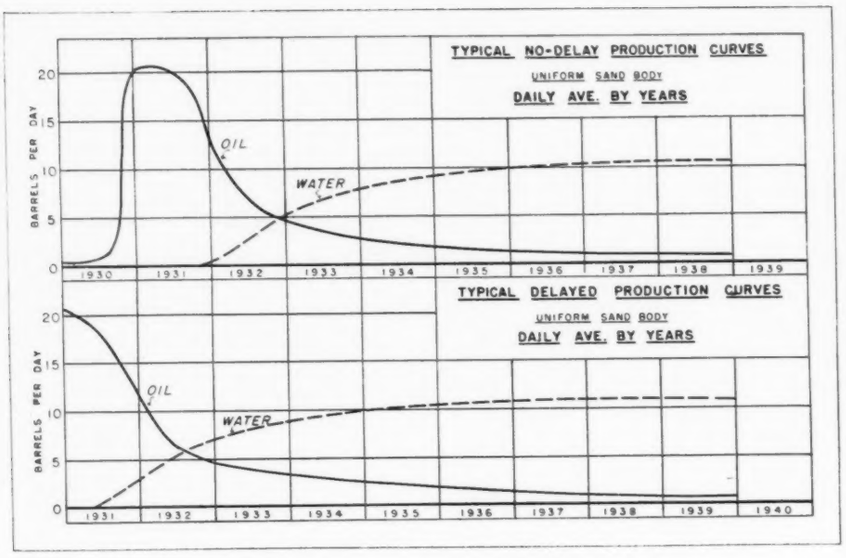


Fig. 1. Typical No Delay and Delayed production curves

A permeability profile of an oil sand suitable for delayed drilling is shown in Fig. 2, together with the three stages of the flood's progress through the sand.

This method was tried in areas where bypassing had caused serious trouble, and found to be a success. Oil recoveries increased in numerous instances. Torrey[1] reported one specific case in which the oil recovery had been increased from 1300 bbl. per acre to slightly more than 4000 bbl. per acre by delayed flooding. Torrey also stated that there was little doubt that the delayed drilling of oil wells would increase the effectiveness of water-flooding operations, provided the water is introduced into the sand at a balanced rate through each intake well and thereby preventing a concentration of the oil off-center in the five-spot square.

On a small lease or property, it would be possible to operate delayed drilling in the recommended manner, but it is not possible to maintain an absolutely balanced flood on a large property that is constantly undergoing development. Only a portion of the property can be developed at a time and the water from the edge wells is certain to get beyond control.

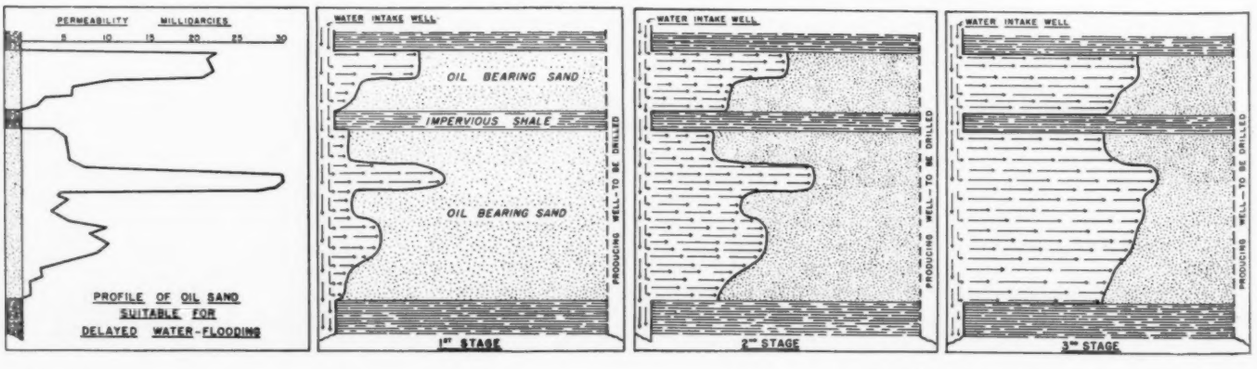
Forced drilling shutdowns due to curtailment caused by the low price of crude oil, or other reasons, will seriously interfere with a delayed drilling program. The equilibrium of the intake wells cannot be maintained and the advancing flood becomes unbalanced to varying degrees. With these points established, the chief purpose of this article now is to analyze and subdivide further the delayed system of flooding into subordinate classifications all of which fall under the same general heading. By this means, it is believed that a much more comprehensive and complete understanding will be evolved.

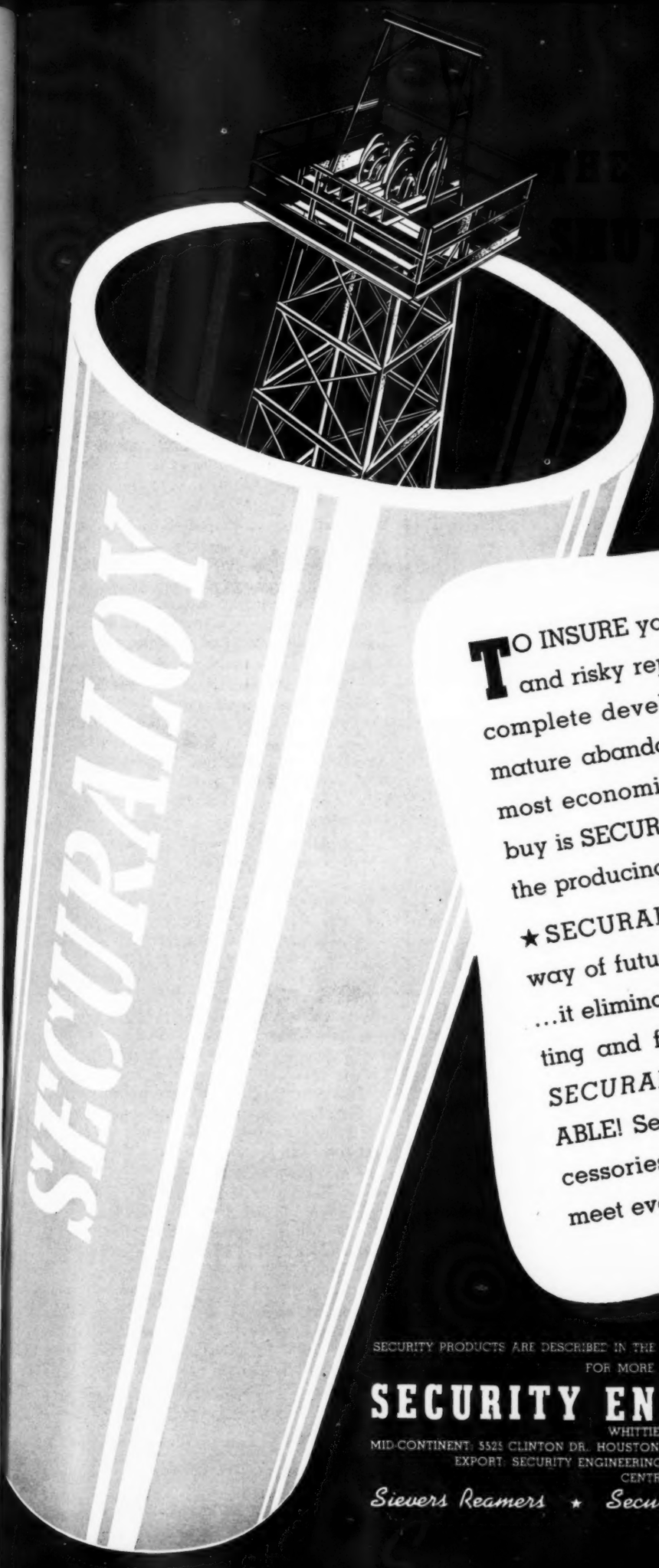
A detailed study of the production records of the producing wells of a large property in the Bradford field has revealed certain specific information particularly concerning the methods of flooding now in use. The wells on this property represent a varied assortment of different periods of delay. Some of the wells were not delayed, so that the production data from such undelayed wells have been invaluable for comparative purposes. As all five-spots studied are on the same property and have been subjected to the same general conditions, the study has been as closely controlled as is possible in the field. The results therefore carry unusual significance.

The producing sand on this particular property is uniform without any streaks of high permeability. The average permeability value lies between 3 and 6 millidarcys. The average porosity value is 14 percent. Oil saturation, determined by the retort method, is between 40 and 45 percent, whereas the connate water percentage ranges from 20 to 25 percent. The average drilling depth to the top of the Bradford sand is 2100 ft. A uniform well spacing of 300 ft. (water well to water well) has been followed and a maximum pump pressure of 700 lb. has been used on all the water intake wells. In some instances, this pressure has been imposed gradually; but in most instances, the water was turned in the well at the maximum line pressure being carried at that time. It is interesting to note that the applied pressure on this particular property has been increased within recent years to 1000 lb., but for most of the data contained herein, 700 lb. was the highest encountered pump pressure. All wells are pumped by individual electric-driven 3-hp. pumping

[1] "The Water-Flooding of Oil Sands," by P. D. Torrey, Illinois Geological Survey Circular No. 23-B.

Fig. 2. Schematic drawing showing profile of an oil sand suitable for Delayed water-flooding, together with the three successive stages of the flood's progress through the sand





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jacks. Individual 10-bbl. receiving tanks were placed at each oil well and a daily gauge was made of all fluid pumped during a period of 8 years.

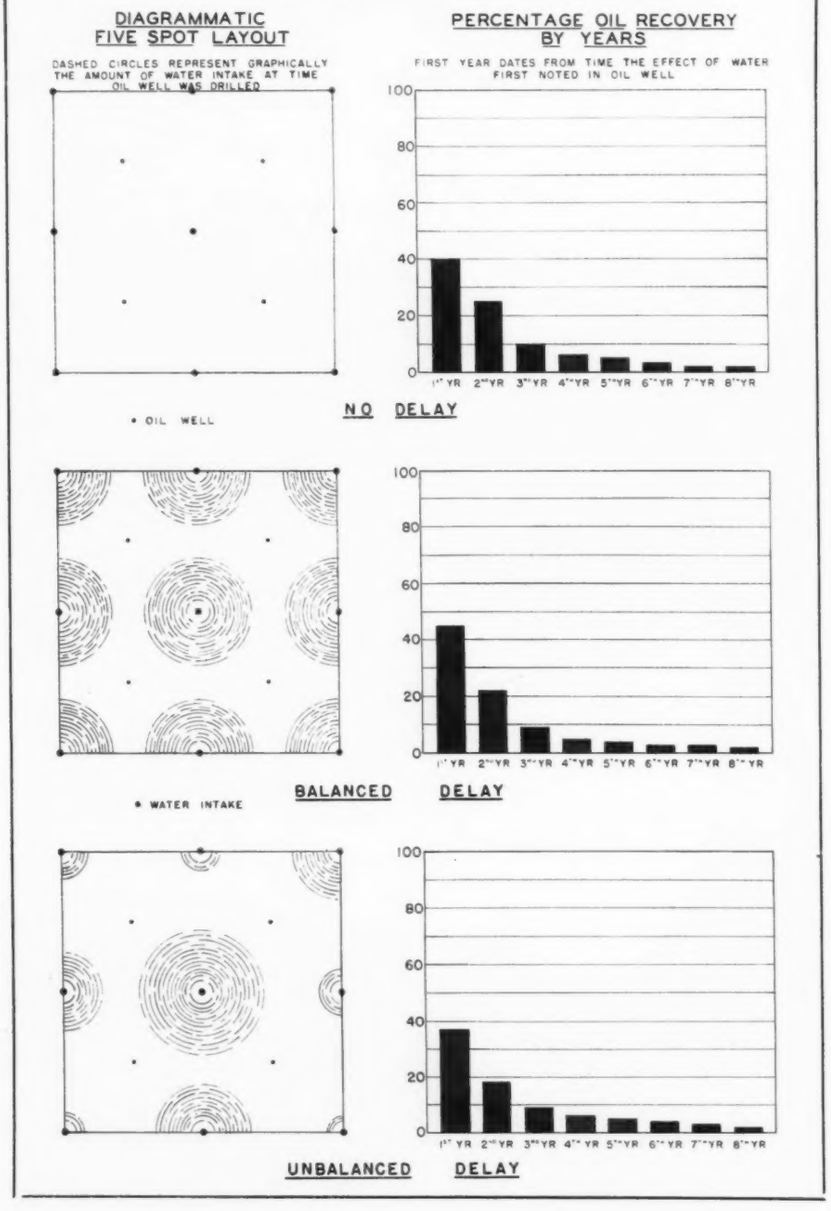
There was no great variation in the amount of water injected into the intake wells on this property; it may be said, therefore, that all intake wells took water uniformly.

The principal factor to be considered when attempting an analysis such as this is the variability in sand thickness. In all wells studied, the sand thickness varied from 25 to 40 ft. In order to reduce all data to a comparable basis, the results given are computed on an acre-ft. basis.

For the sake of segregating the different methods of flooding with a view toward selecting the type of flood that would yield the maximum recovery in bbl. per acre, the producing wells described have been divided into six distinct groups, each of these groups representing actual conditions that are certain to appear at some stage of a delayed drilling program. They will be discussed in their respective order.

1. **No Delay.** The individual five-spots studied under this classification are those wherein the oil-producing well was drilled first, and put to pumping before the surrounding water intake wells were drilled. As previously explained, this type of operation provides an early period of small production that also tends to increase the pumping costs.

Fig. 3. Diagrammatic five-spot layout for different types of delay in a uniform sand, with percentage oil recovery by years


DIAGRAMMATIC FIVE SPOT LAYOUT
DASHED CIRCLES REPRESENT GRAPHICALLY THE AMOUNT OF WATER INTAKE AT TIME OIL WELL WAS DRILLED
PERCENTAGE OIL RECOVERY BY YEARS
FIRST YEAR DATES FROM TIME THE EFFECT OF WATER FIRST NOTED IN OIL WELL
100
80
60
40
20
0
1ST YR 2ND YR 3RD YR 4TH YR 5TH YR 6TH YR 7TH YR 8TH YR
• OIL WELL
NO DELAY
• WATER INTAKE
BALANCED DELAY
UNBALANCED DELAY

Provided the sand body is uniform without highly permeable sections, this method of operation yields satisfactory results.

It is well to mention that the "first year" referred to in this grouping begins when the effect of the water is first noticeable in the oil well. The period of small production is slight but is included in the first year recovery in order that the information may be comparable with delayed drilling data.

2. **Balanced Delay.** Under this classification falls all those five-spot groupings that had water turned into all four water-intake wells at the same time or within two months of each other.

Theoretically, a Balanced Delay represents a highly efficient method of water-flooding provided the water intake can be controlled uniformly. Unfortunately this uniformity cannot be maintained in large scale operations. It is obvious, however, that delayed drilling by this method is an excellent manner in which to cope with bypassing problems.

Peak production is usually reached immediately after the oil well is drilled. The appearance of water in the oil well is quite often at a later date than if the well were not delayed, although this does not hold as a general rule. When this does occur it is an aid in reducing the lifting cost.

3. **Unbalanced Delay.** The five-spot groupings included in this category are those in which the water was put into the intake wells at different times and over a period of months, not simultaneously as with a Balanced Delay. This is the condition that usually prevails when a water-flood development is undertaken on a large scale. It is quite evident that the ultimate recovery from five-spots restricted to this grouping will be considerably less than that obtained from a Balanced Delay. In the majority of instances, poor production was the result of drilling the water wells at varying periods of time, and forcing water into them as soon as completed.

4. **Two Sides Balanced.** This condition is often encountered on large-scale drilling programs developed in unit blocks. First, one block of acreage is drilled and water forced into the intake wells. At some later date, the adjoining block is drilled and water injected into the sand. Consequently, where the two blocks join, much more water will have entered the sand on one side than the other, resulting in a type of delay referred to as Two Sides Balanced.

Another method by which a great many five-spots are developed is the

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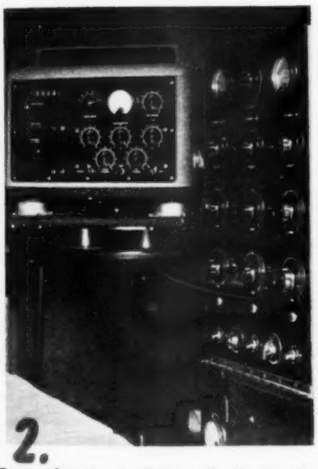
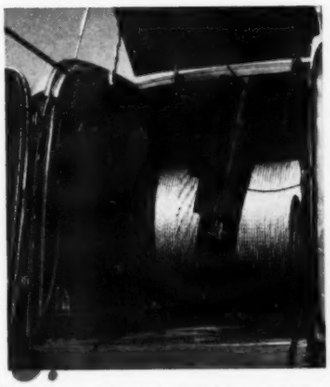


2. From the Control Panel all circuits are finally adjusted before a run is made to eliminate the "human element" and any chance of error from this cause.



4. Simple, yet extremely sensitive mechanical controls of the efficient hoisting equipment allow faster recording speeds with safety. All curves are recorded to the bottom foot of hole.

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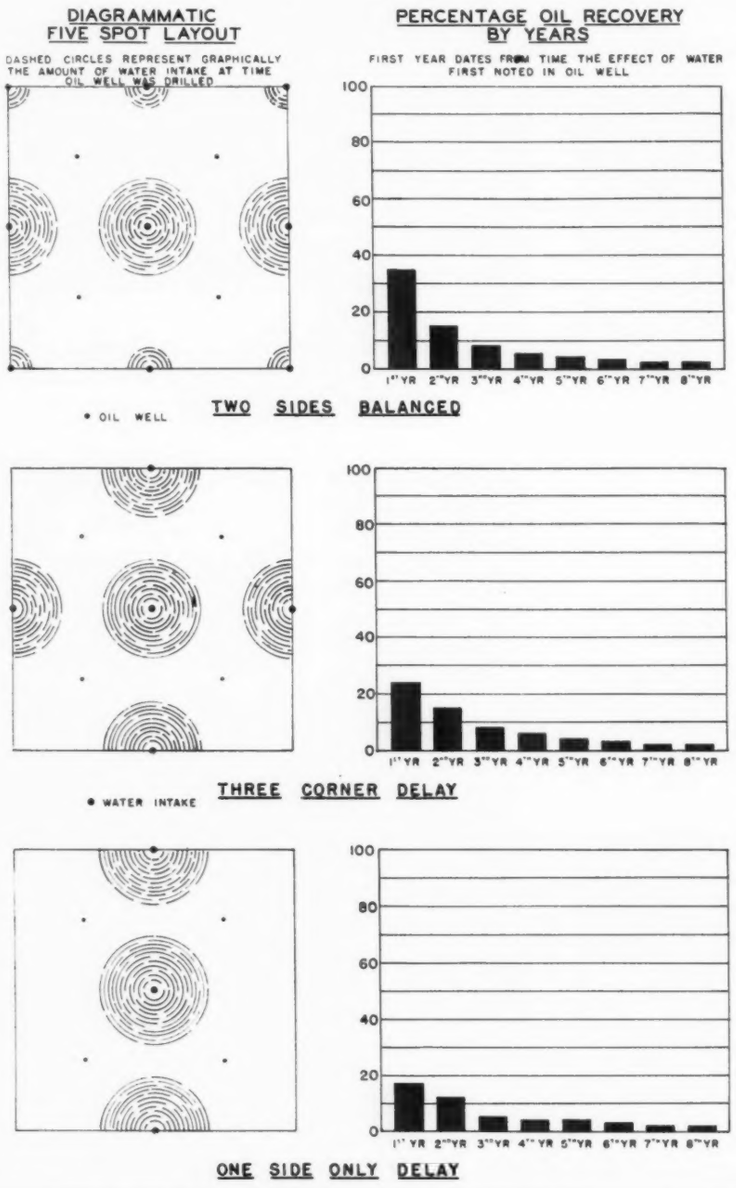
plan of encircling a developed block with a row of new water wells each year. Balance can be maintained on one side only. This can be corrected to a certain extent by drilling the intake wells in pairs, thereby assuring a Balanced Delay between the two rows, although the outer edge will present the same difficulty to the next tier of wells.

Fig. 4. Diagrammatic five-spot layout for different types of delay in a uniform sand, with percentage oil recovery by years


DIAGRAMMATIC FIVE SPOT LAYOUT
DASHED CIRCLES REPRESENT GRAPHICALLY THE AMOUNT OF WATER INTAKE AT TIME OIL WELL WAS DRILLED
PERCENTAGE OIL RECOVERY BY YEARS
FIRST YEAR DATES FROM TIME THE EFFECT OF WATER FIRST NOTED IN OIL WELL
100
80
60
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0
1ST YR 2ND YR 3RD YR 4TH YR 5TH YR 6TH YR 7TH YR 8TH YR
• OIL WELL
TWO SIDES BALANCED
• WATER INTAKE
THREE CORNER DELAY
ONE SIDE ONLY DELAY

5. Three Corner Delay. Included in this group are all those five-spots in which the water drive is from only three corners of the square at the time the oil well is drilled. This type of delay is not so prevalent as the other mentioned groups, but nevertheless does occur and must be considered in any delayed flood analysis such as presented herein.

6. One Side Only Delay. This classification includes all those five-spots whereby water is forced into the sand from one side only. Like the above-mentioned classification it is the exception rather than the rule. Whenever it does occur, all other conditions being equal, the anticipated oil recovery cannot be more than one-half that which would be expected under a normal Balanced Delay.

Complete data representative of each of the above groups were available for this study and the results are tabulated in Table 1, and presented graphically in Figs. 3 and 4.

Information was first computed on a bbl. per acre yield by years. These data in turn were interpreted in terms of bbl. per acre-ft. yield. Assuming an average total recovery figure of 175 bbl. per acre-ft., all data were calculated on a percentage basis and the resultant information presented herewith.

It is interesting to note by reference to Table 1 and the diagrams contained in Figs. 3 and 4 that after the third year, the percentage recovery for all six flood types is practically the same. In other words, in order to operate in the most efficient manner and recover the maximum amount of oil obtainable, it is necessary that most of it be produced in the first three years after the oil wells are drilled.

A highly important phase of waterflood production is the oil-water ratio of the producing wells. In order to present accurately the actual oil-water results for each of the six methods of production under discussion, a set of composite production curves is presented. These are shown in Figs. 5

TABLE 1

Percentage of oil recovery by years for various types of delayed water floods—uniform sand

Type of flood	No. of five-spots included	Acreage involved	Percentage yield—based on 175 bbl. per acre-ft. recovery								Percentage recovered by end of 8 years
			1st yr.	2nd yr.	3rd yr.	4th yr.	5th yr.	6th yr.	7th yr.	8th yr.	
*No Delay	5	10.3	40	25	10	6	5	3	2	2	93
Balanced Delay	15	31.0	45	22	9	5	4	3	3	2	93
Unbalanced Delay	18	37.9	37	18	9	6	5	4	3	2	84
Two Sides Balanced	36	74.4	35	18	8	5	4	3	2	2	74
Three Corner Delay	4	8.3	24	15	8	6	4	3	2	2	64
One Side Only Delay	11	22.7	17	12	5	4	4	3	2	2	49

*First year period begins when the effect from the water-intake wells is first noted in the oil well. All other first year delayed periods date from the drilling of the oil well.

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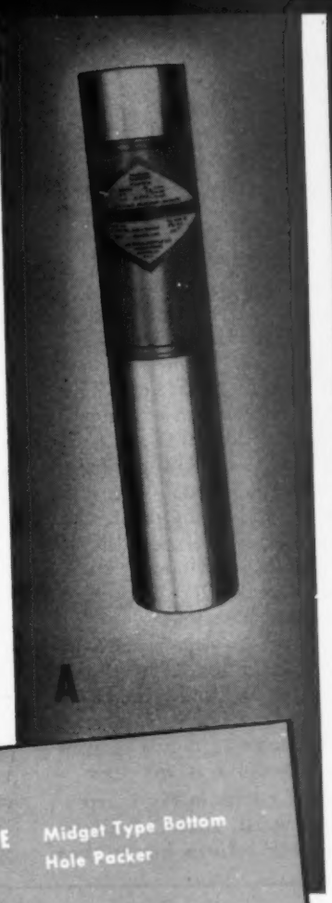
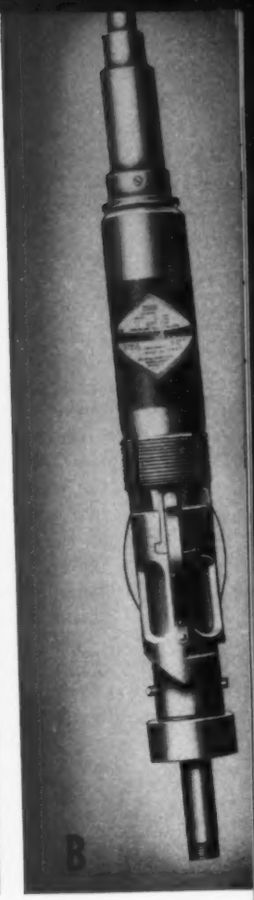
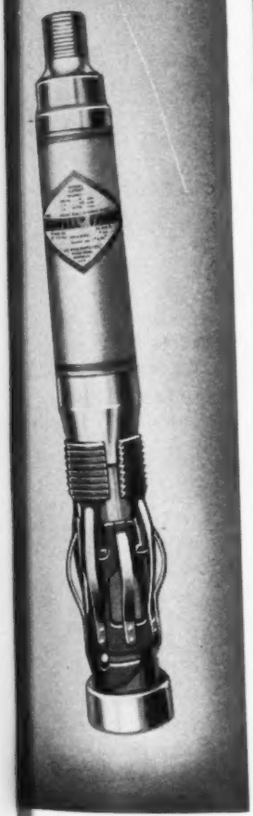
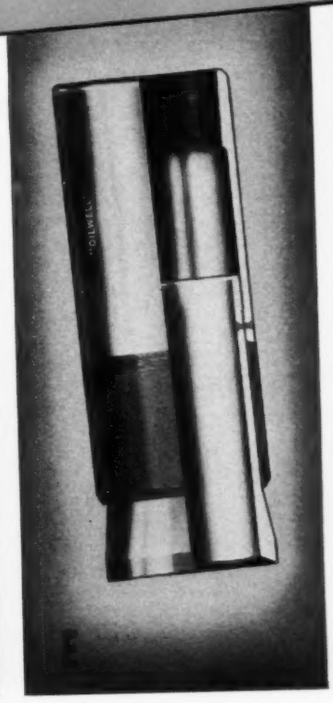




A	Casing Anchor Packer	E	Midget Type Bottom Hole Packer
B	Pressure Relief Packer	F	Full-Expanding Tubing Anchor Packer
C	Hook Wall Tubing Size Packer	G	Regular Gas Anchor Packer
D	Step Expanding Gas Anchor Packer		





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to 10, inclusive. Both oil and water curves are computed on a bbl. per acre-ft. basis and plotted over a period of 8 years. Each will be discussed in its respective order.

The curves shown in Fig. 5 represent the average oil and water production in bbl. per acre-ft. for 5 five-spots (10.3 acres) that were not delayed. These curves are particularly interesting because of the low oil-water ratio over the 8-yr. period. The slow decline of the water curve is probably due more to a gradual sand plugging rather than to the fact that it was not delayed. Water in a producing well under water-flood development usually shows an increase rather than a decline.

The graph in Fig. 6 depicts the average oil-water ratio for 15 five-spots (31.0 acres) that fall under the classification of Balanced Delay. The water in this group shows a gradual increase although not excessive at any time.

The group of curves in Fig 7, representing Unbalanced Delay, indicates that the oil-water ratio is higher than either of the two preceding groups. These data were obtained from 18 five-spots (37.9 acres). It is interesting to note that considerable water is produced the first year.

A correspondingly higher oil-water ratio is to be noted on the curves in Fig. 8, compiled from a Two Sides Balanced Delay. There are 36 five-spots (74.4 acres) included in this grouping.

The oil-water ratio shown in Fig. 9 is low in the 4 five-spots (8.3 acres) studied under Three Corner Delay. It is to be noted that the total fluid curve is correspondingly low.

The curves in Fig. 10 represent graphically the oil-water ratio for those wells that are classified as One Side Only Delay. There were 11 five-spots (22.7 acres) included in this group. Both oil and water production is shown to be low.

A sand body with a wide range of permeability values has always been one of the major water-flooding problems confronting oil producers in the Bradford area. Within recent months a great deal of attention has been paid to selective shooting of the wells.

A very comprehensive study of this subject has been contributed by Ryder.[2]

Briefly, this method requires a thorough knowledge of the sand and accurate placement of the nitroglycerin in order that the more permeable sections receive a smaller charge of explosive than the tighter sections.

Favorable results have been reported by various operators who have been paying special attention to the shooting of the producing horizon. Particular mention is made of selective shooting herein, as it is considered highly important in any flooding method.

None of the wells included in this study was selectively shot.

It is obvious that delayed drilling in a heterogeneous body of sand in conjunction with selective shooting represents the best known method of operating efficiently. As previously explained, this was the chief purpose for introducing the delayed method.

It was common belief, however, that delayed drilling would increase the oil recovery accordingly on uniform sand as well as on the non-uniform sands. The study presented herein of a uniform sand body has attempted to show that no particular benefits have been derived from delayed drilling. It is to be stressed that these results apply only to this particular property and they cannot at this writing be construed as representative for the entire field. The accumulation and interpretation of accurate production information from all sections of the field will be necessary before arriving at any definite conclusions.

In this particular property it is readily seen that delayed drilling was not responsible for increasing recovery more than could be obtained by conventional methods, which the writer refers to as No Delay. This is no doubt due to the ideal uniformity and low permeability of the sand body. All data revealed in this analysis would indicate that delayed drilling cannot be adapted to a uniform sand body with the same anticipated percentage increase in recovery that would be expected from a sand with an uneven permeability range.

There is no necessity for delayed drilling in sand of this order. When attempted, all types of delay as shown are encountered and the corresponding loss of recoverable oil is high. This percentage oil recovery interpreted in bbl. per acre may mark the difference between profit and loss.

Composite production curves compiled from actual data showing oil-water ratio over a period of years for different types of delay in a uniform sand body

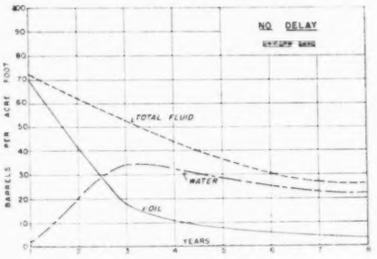

Fig. 5

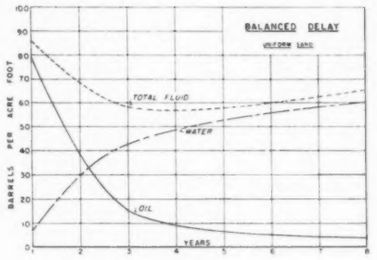

Fig. 6

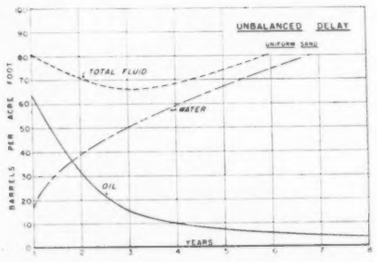

Fig. 7

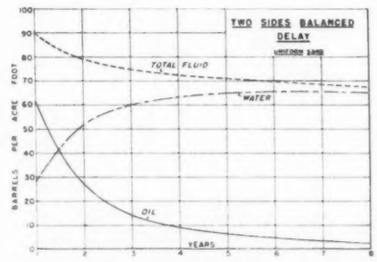

Fig. 8

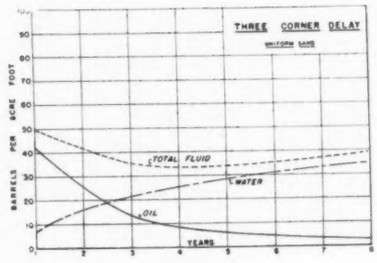

Fig. 9

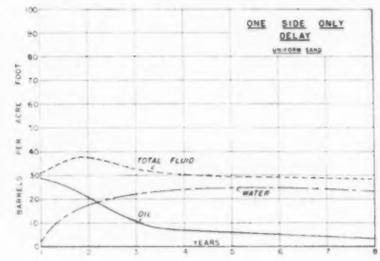

Fig. 10

[2] "Practical Water-Flooding Efficiency in Oil Production," by H. M. Ryder, presented at Eastern District A.P.I., Division of Production, Pittsburgh, Pennsylvania, April 4-5, 1939.

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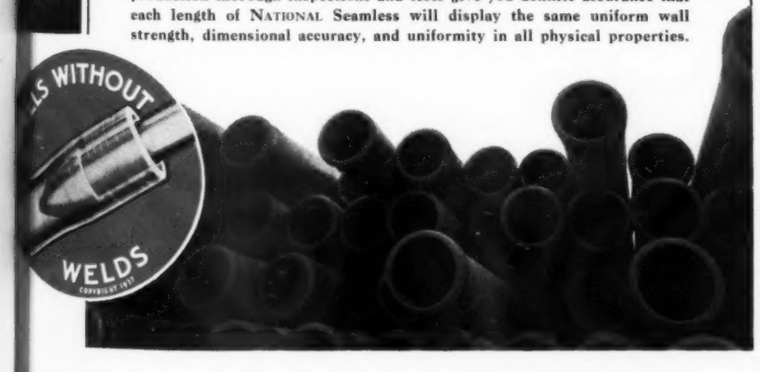

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Methods of Studying Microbiological Anaërobic Corrosion of Pipe Lines

PART 2 (Conclusion)

By RAYMOND F. HADLEY

Electrical Engineer, Susquehanna Pipe Line Company

SOME investigators may feel that in spite of the complicated analysis that must be made to determine the presence of the organic compounds that are available to the sulphate-reducing bacteria, an investigation could be undertaken that would include not only determinations of the organic compounds available, but also concentration of SO_4 and H_2S as well as CO_2 tension in the soil-water solution. Whereas an analysis from this angle is perfectly possible, the volume of work associated with such an investigation appears to make it much less desirable than an approach made from the study of the metal salts that result from the bacterial metabolic processes. In this respect it can be stated that our field parties have been making routine tests that include pH, SO_4, and CO_2 determinations at each inspection location. Of these three determinations, the pH has been the most useful, as it has enabled us with a fair degree of accuracy, to state whether serious bacterial corrosion may, or will not, be found at any given location[20]. A great number of SO_4 determinations have been made, but to date they have shown very little correlation with the degree of corrosion. CO_2 determinations have also been made at a smaller number of locations and to date we have not established any appreciable correlation between the CO_2 tension in the soil water and the degree of corrosion. We believe, however, that a sufficent number of CO_2 determinations have not been made thus far to eliminate conclusively a possible correlation.

Life of Pipe

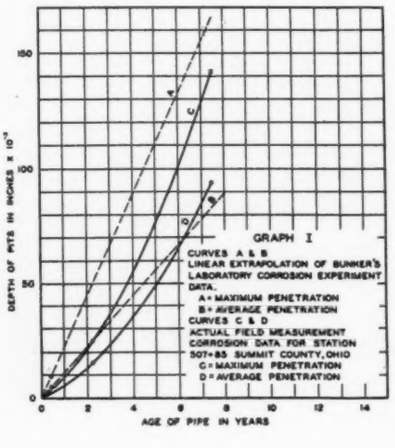
One of the first questions that naturally comes to mind in regard to the microbiological anaërobic corrosion process is how long a steel pipe of given wall thickness will last in a location, such as a swamp, where all of the conditions are favorable for the growth of the sulphate-reducing bacteria. Unfortunately this question is not easily answered because of the rather wide variation of the many factors affecting the growth of the sulphate-reducing bacteria, that may occur from point to point in any given location.

Laboratory experiments have been carried out by H. J. Bunker[19] in which mild steel disks were exposed to a nutrient lactate-sulphate solution that was inoculated with pure cultures of

The biography and photograph of the writer of this article can be found on page 171 of the March issue of *The Petroleum Engineer*, in connection with Part I.

Sporovibrio desulfuricans. During the experiment the nutrient solution was replenished nine times thus assuring optimum conditions for growth. The duration of exposure was 156 days. The loss of weight of the specimen in the inoculated medium was 0.3774 grams. The average penetration was 0.023 cm. on the upper surface and the penetration due to general corrosion, 0.005 cm. on the lower surface. Bunker states, "If all of the factors in the soil were similar to those in the above experiment and remained constant over the whole period this rate of corrosion would be equivalent to the penetration of a steel main 4 mm. thick in about 7.5 years." These data have been plotted in Graph I, the extrapolation of Bunker's data being shown in dashed lines.

Graph I


DEPTH OF PITS IN INCHES X 10⁻³
AGE OF PIPE IN YEARS
GRAPH I
CURVES A & B
LINEAR EXTRAPOLATION OF BUNKER'S LABORATORY CORROSION EXPERIMENT DATA.
A = MAXIMUM PENETRATION
B = AVERAGE PENETRATION
CURVES C & D
ACTUAL FIELD MEASUREMENT CORROSION DATA FOR STATION 507+85 SUMMIT COUNTY, OHIO
C = MAXIMUM PENETRATION
D = AVERAGE PENETRATION

Actually in practice, we have found in no less than four instances that failure of a pipe of equivalent wall thickness would have occurred in that time in swamps known to be favorable for the growth of the sulphate-reducing bacteria and from which the sulphate-reducing bacteria were actually isolated. Although our field measurements of pit depths in swamps undergoing bacterial corrosion (at time = 7 years) correlate extremely well with the linear extrapolation of Bunker's data, it has been observed by the writer and by others in this company who have had the opportunity to examine the pipe in locations undergoing active bacterial attack, that the actual curve of pitting as a function of time is not linear, but a decided increasing rate curve.

Curves showing the pit depth plotted against time are shown in Graph I and Graph II for three rather widely separated locations in Ohio.

The writer is cognizant of the fact that the sketchiness of the data precludes the drawing of any concrete conclusions from these graphs. The value of the curves, however, lies in the fact that they are all similar in shape and illustrate that tendency of bacterial corrosion noted in the previous paragraph. The test holes from which the data for curves C and D of Graphs I and II were obtained were dug so as to include one-half of the pipe examined in the first examination and an equal distance of undisturbed backfill.

From the three curves showing maximum penetration the average derivative for each year has been determined and plotted to show the change of pitting rate with time. It is of especial interest to note that in each of the bacterial corrosion locations plotted, the corrosion rate increases with time whereas, with the other types of corrosion the corrosion rate is very high at the start and then tapers off, in

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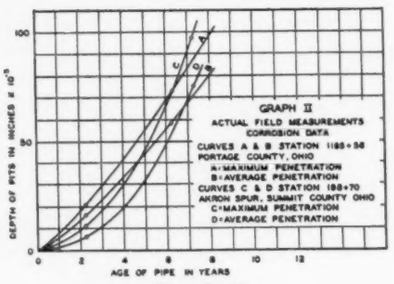


Graph II

some cases becoming zero. It is the opinion of the writer that this pronounced difference in the corrosion rates, and of the corrosion areas, is explained very satisfactorily by the "self stifling" theory of Evans[17], that is to say, that under the anaërobic conditions maintained by the sulphate-reducing bacteria the products of corrosion are maintained in the ferrous state and are not precipitated as a highly insoluble impermeable ferric hydroxide membrane, as is the case under more aërobic conditions, thus allowing active corrosion to proceed over a much greater area.

Fig. 3. Bacterial attack of various metals

A qualitative experiment has been in progress for several months in our laboratory in which mixed cultures of the sulphate-reducing bacteria were grown under anaërobic conditions in 250 ml. ground-glass-stoppered bottles with cellulose (filter paper) as the only source of organic material. In each bottle was placed a small sterilized piece of metal, in an effort to ascertain the relative effect of the microbiological anaërobic corrosion on several different metals. The metals used in the experiment together with the results of the experiment are shown in Table 5 and Fig. 3.

A photomicrograph of the microorganisms used for the inocluation of the samples is shown in Fig. 4. The sulphate content of the water used in the experiment underwent a rather pronounced reduction thus indicating that the sulphate-reducing bacteria were active in all of the cultures.

In approximately seven days a pronounced blackening was noted in the bottles containing carbon steel and lead, and a white discoloration could be noticed in the bottle containing zinc. The contents of the other bottles appeared unchanged. Approximately one month after the experiment was started, a considerable quantity of a black ferrous precipitate could be noted in the bottle containing the carbon steel together with what appeared to be fairly active decomposition of the cellulose. At the same time, in the bottle containing lead an equal degree of discoloration appeared to be present; the decomposition of the cellulose, however, had apparently not progressed to such an extent as in the case of the carbon steel. The bottle containing the zinc did at this time contain a heavy precipitation of a white zinc salt, together with a greater degree of decomposition of the cellulose than in the case of lead, but not so much as the sample containing the carbon steel. The other two bottles containing copper and stainless steel appeared to be unchanged. At the end of 52 days the chrome oxide film of the stainless steel appeared to break down, overnight, with the resultant black discoloration due to the precipitation of ferrous salts. Following this breakdown of the chrome oxide film, the culture media became somewhat cloudy whereas before the failure of the film it had been clear.

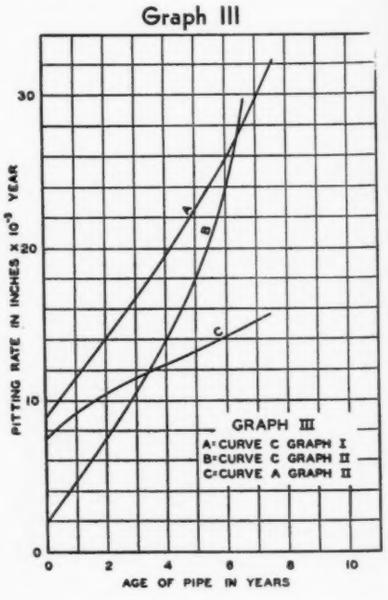
The experiment was discontinued after 111 days, the visual results being very much the same as those obtained at the end of one month, except that a general deepening of discoloration in the bottles containing the carbon steel, lead, and zinc was observed. The copper appeared to be unaffected and the stainless steel remained in much the same condition that was noted immediately following the breakdown of the chrome oxide film. This experiment was originally prepared as a qualitative experiment; so much interest has been shown, however, in the results, which have been most interesting and enlightening, that it is being repeated on a quantitative basis.

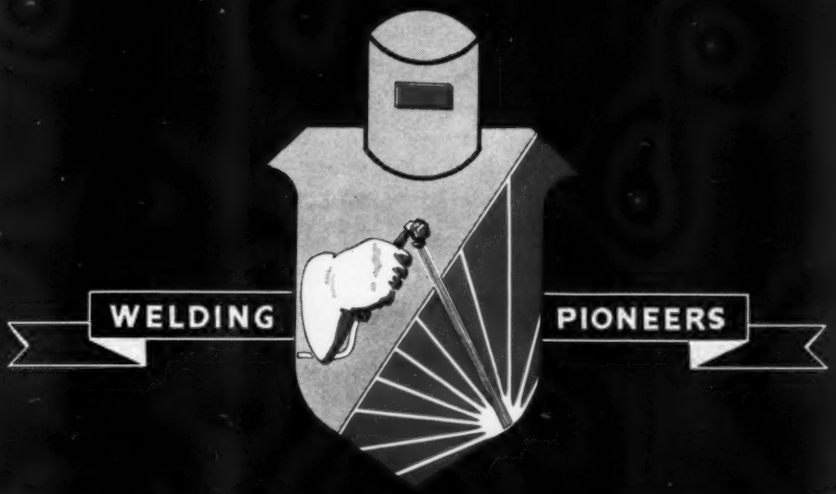
Pipe Protection

All investigations of microbiological anaërobic corrosion processes by corrosion engineers must of necessity be carried out with the ultimate view in mind of protecting the pipe in locations where abnormal corrosion rates exist. Thus far, our experience with bacterial corrosion seems to indicate that protection of the pipe line can best be accomplished by its complete insulation from the ground and soil water. For this purpose we are using petroleum asphalt encased in a wooden box constructed of one of the durable woods. The pipe is supported and centered by vitrified porcelain cleats having a maximum water absorption of less than one tenth of one percent. Protection of this type has now been in use by this company for a period of 9 years in locations where we know the sulphate-reducing bacteria are active, and recent examinations of the pipe in these locations show that the corrosion rate has thus been lowered to a negligible value. There are undoubtedly other types of coatings commercially available in this and foreign countries that will give equally dependable service. The subject of pipe coatings, however, is one that the writer does not care to include in the scope of this article.

The use of cathodic protection currents for the mitigation of this microbiological anaërobic corrosion also has possibilities. Experiments are now in progress in our laboratory that may yield additional information regarding the mitigation of this corrosion by cathodic currents. Unfortunately these experiments are not yet complete and the data are therefore not available at the time of this writing. Theoretical considerations seem to indicate that the economical use of cathodic protection in locations undergoing active bacterial corrosion would be of doubtful value.

Graph III





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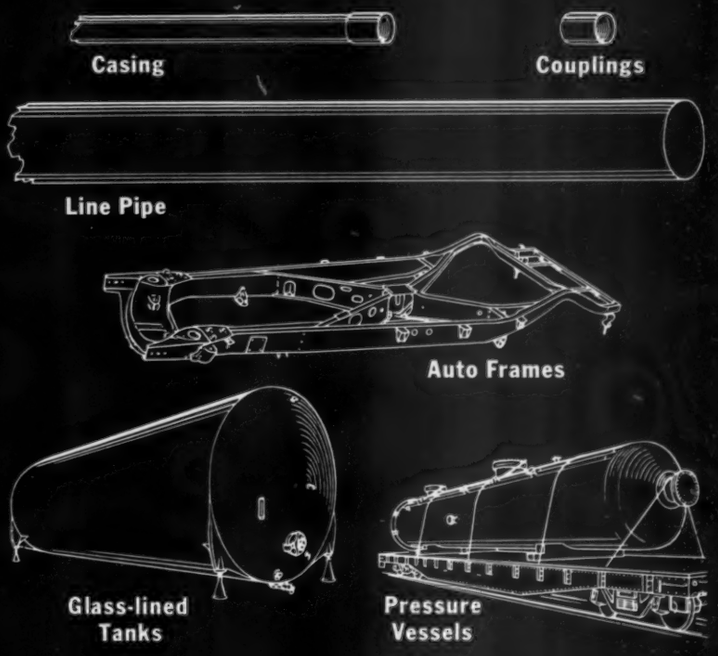

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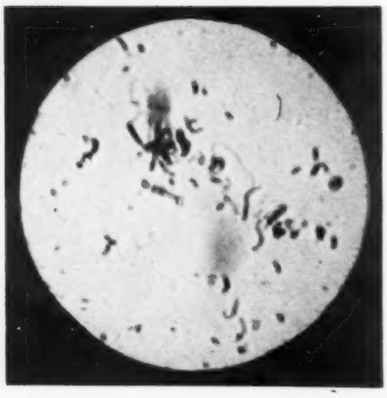

Fig. 4. Mixed culture of microorganisms. Note presence of sulphate-reducing Vibrios

Our field experience, however, in one location where active microbiological anaërobic sulphate reduction is in progress indicates that cathodic currents can be advantageously used to minimize this type of corrosion. The necessary data from the location referred to are, unfortunately, not obtainable as we are unable, because of certain physical conditions (coated pipe 2-15 ft. deep in bottom of lake of 12 ohm-cm. resistivity) to ascertain the current densities now used or the pipe-ground potentials that now exist. An examination of 8 ft. of the pipe in this lake in 1939 revealed that, although vigorous sulphate reduction was taking place in the bottom of the lake, such pitting of the pipe as could be observed in the patches where the coating was found to be defective was negligible. Enrichment cultures of the active sulphate-reducing bacteria were grown from the ferrous salts on the pipe surface and from the muck in the bottom of the lake. The HCl test showed only the smallest trace of FeS, although a considerable quantity of $FeCO_3$ was found on the pipe; thus again the quantity of FeS in the corrosion products correlates with the degree of corrosion.

Acknowledgments

In closing, the writer desires to express his appreciation to Dr. R. L. Starkey of the New Jersey Agricultural Experiment Station for his criticism of this manuscript, to Dr. J. M. Pearson of the Susquehanna Pipe Line Company for many valuable suggestions and appreciated constructive discussions of the many problems confronting us in this study. Acknowledgment is also expressed to D. F. Van de Water of the Susquehanna Pipe Line Company for his work in compiling the data relative to the distribution of microbiological anaërobic corrosion and for the tedious work of measuring the relationships of uncorroded to corroded areas.

Fig. 5. Third transfer of enrichment culture in lactate medium

BIBLIOGRAPHY

[1]Irvine, R., *J.S.C.I.* 10, 237 (1891).

[2]Gaines, R. H., *Ind. Eng. Chem.* 2, 125 (1910).

[3]Grzeschick, T., *Chem. Ztg.* 36, 505 (1912).

[4]V. Savyalov, "Hydrogen Sulphide Fermentation in Medicinal Black Muds," *Centralblatt fur Bakteriologie, Parasitenkunde u. Infektionskrankheiten,* Vol. 29, No. 15/17, pp. 440-447, November 29, 1913.

[5]Friend, J. N., Carnegie Scholarship Memoirs (Iron and Steel Inst.) II, (London, 1922).

[6]Bengough, G. D. and May, R. J., Inst. Metals, 32, 81 (1924).

[7]Bastin, Edson S., Greer, Frank E., Merritt, C. A., Gail, Moulton. "The Presence of Sulphate-Reducing Bacteria in Oil Field Waters," *Science,* January 1, 1926.

[8]Bastin, Edson S., "A Hypothesis of Bacterial Influence in the Genesis of Certain Sulphide Ores," *The Journal of Geology,* Nov.-Dec., 1926.

[9]Bastin, Edson S., "The Problem of the Natural Reduction of Sulphates," *Bulletin of the American Association of Petroleum Geologists,* Vol. X, No. 12, December, 1926.

[10]Bastin, Edson S. and Greer, Frank E., "Additional Data on Sulphate-Reducing Bacteria in Soils and Waters of Illinois Oil Fields," *Bulletin of the American Association of Petroleum Geologists,* Vol. 14, No. 2, Feb., 1930.

[11]Baars, J. K., "Over Sulfaatreductie door Bacterien," Dissertation, Delft, (1930).

[12]Kluyver, A. J., *The Chemical Activities of Micro-organisms,* University of London Press, Ltd., pp. 69-75, (1931).

[13]von Wolzogen Kühr, C. A. H., *Water and Gas Jaarg,* 726, p. 277, 123; 14 26, p. 259, (1930); 15 1, p. 6, (1931).

[14]Beckwith, T. D., and Moser, J. R., "The Reduction of Sulphur-Containing Compounds in Wood Pulp and Paper Manufacture," *Journal of Bacteriology,* Vol. XXIV, July, 1932.

[15]von Wolzogen Kühr, C. A. H., and Van der Vlugt, L. S., *Water,* August, 1934, No. 16.

[16]Thaysen, A. C., "The Microbiological Aspect of Corrosion," *Science of Petroleum,* Vol. III, pp. 2316-2317. Oxford University Press, (1938).

[17]Evans, Ulick R., *Metallic Corrosion Passivity and Protection,* p. 4, Edward Arnold & Company, (1937).

[18]Starkey, R. L., *Archiv f. Mikrobiologie,* 9, 268, (1938).

[19]Bunker, H. J., *Society of Chemical Industry,* Vol. 58, 93-100, March, 1939.

[20]Hadley, R. F., "Microbiological Corrosion of Steel Pipe Lines," *Oil and Gas Journal,* p. 92, September 21, 1939.

TABLE 5

Metal	Start of experiment: Weight of metal specimen, grams	Start of experiment: SO_4 content of water, p.p.m.	Start of experiment: pH of water	Start of experiment: Duration of experiment, days	End of experiment: Weight of metal specimen, grams	End of experiment: Loss of weight of metal specimen, grams	End of experiment: SO_4 content of water, p.p.m.	End of experiment: pH of water
Copper[1]	2.7588	102.0	6.9	105	2.7172	0.0416*	0.34	6.6
Carbon steel[2]	1.3198	102.0	6.9	111	1.2983	0.0215	40.00	6.9
Lead[3]	13.3760	102.0	6.9	105	13.3579	0.0181	0.00	6.3
Stainless steel[4]	6.1630	102.0	6.9	105	6.1623	0.0007	9.06	6.9
Zinc[5]	0.2017	102.0	6.9	105	0.1738	0.0279	0.19	7.4

[1]Electrolytic
[2]Feeler stock
[3]Cable sheath
[4]18-8
[5]C. P. foil
*Loss of weight due to cleaning.

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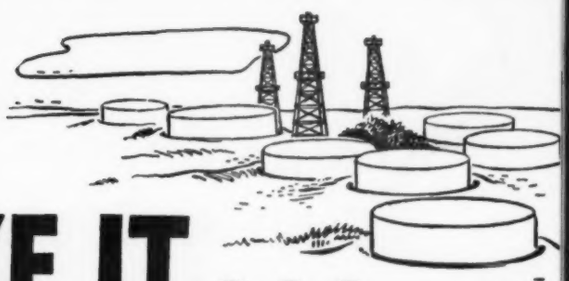

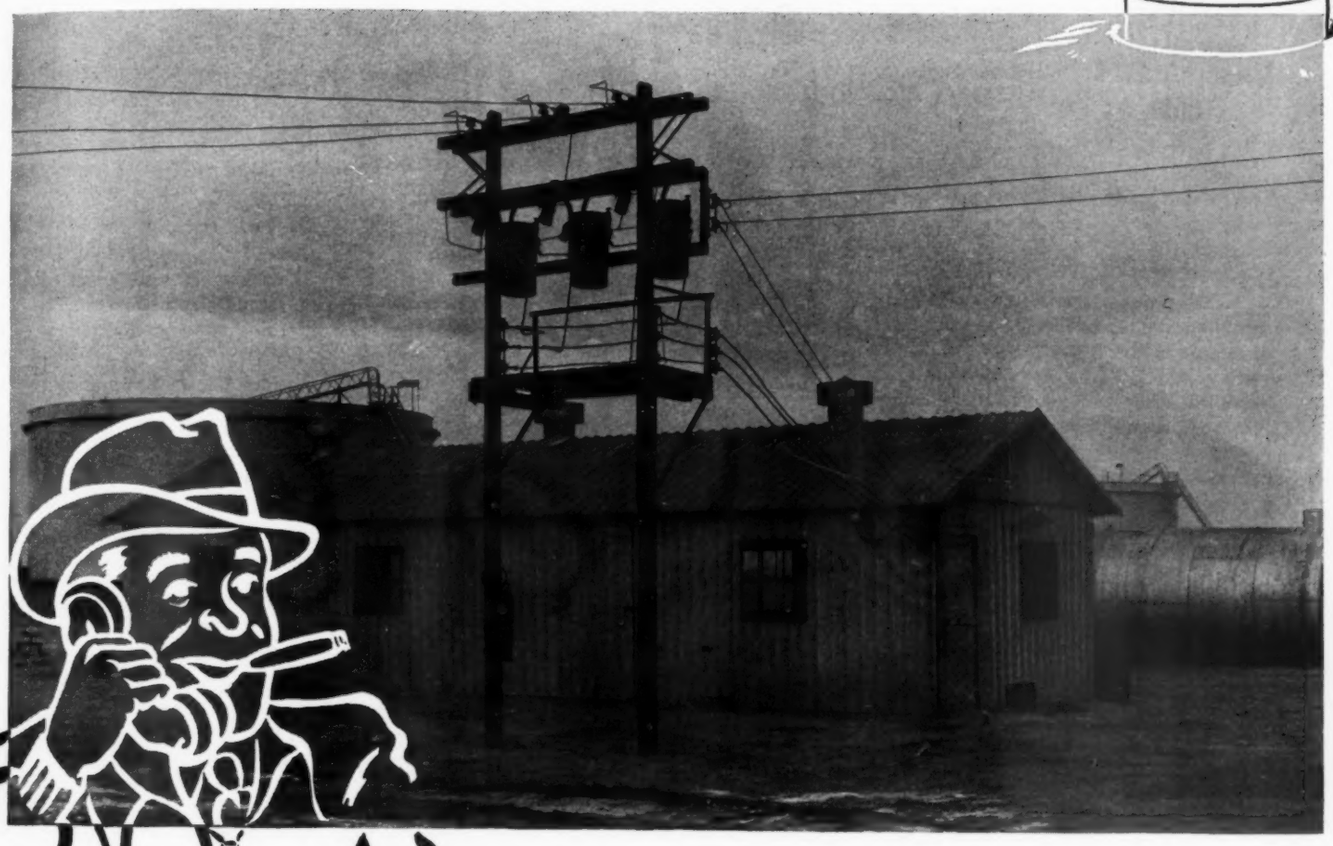

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Deepening and Completing a Well in the Lisbon Field, Louisiana — A Study in Modern Coöperative Practice

Part 3

By PAUL D. TORREY, Geologist, The Sloan and Zook Company
and
FRANK H. MILLER, Petroleum Engineer
Lisbon Exploration Company, Inc.

DRILLING (Continued)

6. Blowouts and blowout prevention. With properly conditioned mud, and with careful observation and testing of the mud to ascertain the possibilities of a gas-cut condition, blowouts should not occur. It seems, however, that notwithstanding all precautions that may be taken, blowouts sometimes take place resulting in certain instances in the destruction of the well, in the loss of large quantities of oil and gas, in the depletion of reservoir energy, and in great hazards to the employees working on the well. In the Lower Marine sands the pressures are high and frequently the volume of gas is large, so that exceptional care should be devoted to the prevention of blowouts. A blowout preventer of ample strength, frequently tested, and properly cemented casing, along with proper mud conditioning are the best assurances against blowouts.

Insofar as the Lisbon area is concerned the record of the Vaughn well does not indicate any danger from blowouts in the various members of the Travis Peak formation. As previously pointed out, therefore, the conditioning of the mud should be based on the consistency that will give the greatest drilling efficiency, rather than upon the possible hazards involved in the encountering of thick, high-pressure gas sands. This does not apply to the Cotton Valley formation.

One of the best indicators of a possible blowout is the gas detector. This apparatus will give, if properly adjusted, a definite warning of the presence of gas in the mud, before the mud is sufficiently reduced in weight to permit a blowout. In fact, as mentioned before, the first indication of the existence of the Vaughn sand was through the gas detector, and when it became evident that detectable quantities of gas were coming through the mud, drilling was immediately discontinued and the weight of the mud was stabilized at 11 lb. per gal. A few days later the electrode of the electrical logging instrument was run in the hole, and the electrical log at once indicated the productive possibilities of the Vaughn sand.

It is very likely that no trouble would have been experienced had the well not been shutdown, with the drill pipe stacked in the derrick, for a period of about 24 hours after the electrical survey had been made. This shutdown permitted the gas to work up through the mud without any rapid means of escape; it is most probable that if the shutdown had been prolonged for a few more hours the well would have blown-in uncontrolled.

Photographs and biographical sketches of the writers of this article can be found on page 155 of the February issue of *The Petroleum Engineer*, in connection with Part 1.

The drill pipe was started back in the hole when the morning tour came to work. When the pipe reached a depth of 1400 ft. the well began to blow out. Fresh mud was circulated from the pit and the flow temporarily killed. The pipe was then lowered to a depth of 4000 ft. and the well again tried to blow out. Fresh mud was again circulated into the hole from the pit and the flow again killed. From this depth to the bottom of the hole, at 8500 ft., the well made almost continual attempts to blow out; at intervals of almost every two or three stands of drill pipe fresh mud was introduced into the hole.

When the pipe was finally carried to bottom the two mud pumps were compounded through the drill pipe, and the blowout preventer closed until additional heavy mud could be mixed, the gas in the mud having lowered its weight by 1.3 lb. per gal.

Weighting material in the amount of 115 sacks was mixed and added to the mud in the pit, and its weight raised to 10.5 lb. per gal. With the pumps still compounded through the drill pipe, the blowout preventer was opened and the pressure gradually reduced through the master gate valve on the return mud flow line. A good show of light oil and a froth of gas bubbles appeared on the mud pit as the pressure was being released, and at times, even with the valve only slightly opened, the mud was blown 20 ft. beyond the shale shaker.

To break-out the gas bubbles more rapidly than could be done by the shale shaker alone, the mud was jetted into the air through one of the "mud guns." Fresh, heavy mud was pumped in through the drill pipe simultaneously as the pressure was relieved through the casing, causing flow to subside gradually. Thirteen hours were required to run the drill pipe to bottom and kill the flow of gas-cut mud.

Although this near blowout indicated most impressively the productive possibilities of the Vaughn sand, it might have proved to be disastrous had the running of the drill pipe into the hole been longer delayed. Furthermore, it might have been much worse had the sand body been thicker and therefore capable of yielding a much larger volume of gas. As long as the mud was being circulated the gas was removed to the extent that it did not have an opportunity to cut the mud materially and thereby reduce its weight.

In other parts of the field, particularly if thicker productive sand bodies should be discovered, and especially should production be found in the highly permeable First Sand, the

(Continued on page 121)

(Continued from page 118)

utmost care at all times should be maintained in order to prevent blow-outs. Truly, the Lower Marine sands, where productive, have "plenty of authority."

7. Mud analyses for oil and gas content. A fluoroscope for the detection of oil, Fig. 5, and a gas detector for the detection of gas, Fig. 6, were employed during the deepening of the Vaughn well. A. L. Smith[15] has described the use of these devices in a paper delivered before the Petroleum Engineering Division of the American Institute of Mining and Metallurgical Engineers at Galveston, Texas, October 7, 1939. The information presented by Mr. Smith, with his consent, has been liberally used in this section of the article.

The fluoroscope consists of a metal box, set on a metal stand, in the top of which are placed two mercury vapor lamps, only one of these being used at a time. At the base of the box, directly below the observation window, there is a small platform on which samples of mud may be placed. On the left side of the box there is a small rectangular door, with hinges at the top, through which the sample is placed, and on the right side there is a circular opening, which may be closed when a sample is being examined, by a machined metallic cap, through which the mud sample may be stirred.

The mud sample to be studied for possible oil content is poured into a shallow tin tray, which is placed on the platform at the base of the apparatus. The mercury vapor lamp is then turned on, and, after allowing a few minutes for the temperature of the lamp to increase so that light will be emitted, the mud sample is then examined through the observation window.

The light from the mercury vapor lamps is particularly high in invisible radiations, which are required for the observation of fluorescent properties. Very minute quantities of oil, mixed with the mud will absorb these invisible radiations, change their natural wave length, and re-emit them with a light wave length visible to the human eye. Thus if microscopic globules of oil, of such size that they may not be detected by ordinary observation, occur in the mud sample, a stirring of the sample will bring these to the surface of the mud where a difference in surface tension causes them to spread over the top of the mud as a very fine film. Crude oil emits a golden-colored light, whereas refined oils emit a bluish-white

[15] "Mud Analysis for Determining Penetration of Petroleum Bearing Formations in a Well Bore," by A. L. Smith, A. I. M. E., Petroleum Engineering Division, October 7, 1939.

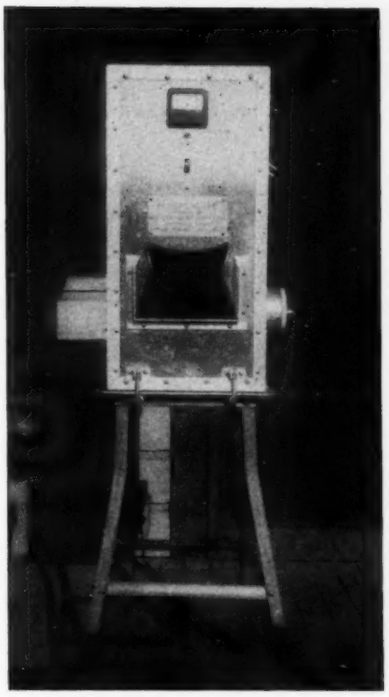
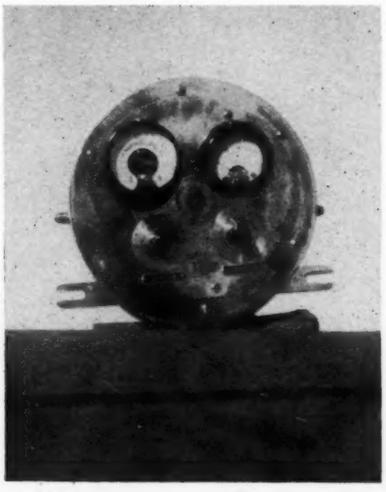


Fig. 5. Fluoroscope used to detect traces of oil

light. There is absolutely no difficulty in distinguishing between crude oil and refined oil. The presence of crude oil in the mud is shown by fine, star-like, golden points on the top of the sample, whereas refined oil generally spreads out as a brilliant iridescent film on the top of the sample.

Owing to the fact that crude oil twice had to be used to lubricate stuck drill pipe, the drilling mud at the Vaughn well uniformly carried small quantities of crude, which never was

Fig. 6. Front view of gas detector



entirely eliminated. It therefore proved to be impossible to ascertain with any accuracy whether oil-bearing sands had been penetrated. It was found, however, that the fluoroscope was very useful in the examination of cores, minute globules or thin films of liquid hydrocarbons being readily seen when fresh core samples were placed on the observation platform.

Some mention of the use of the gas detector has been made previously. This apparatus consists of a metal box in which is placed a separator tank, tilted in the direction of the mud flow stream; vacuum hose lines; an electrical combustion device, and electrical storage batteries. A part of the mud from the return flow line is diverted into the separator tank where it flows over a series of baffles that break-out any gas bubbles that may be present. A suction is applied to the tank by a steam jet set on the outside of the metal box, and all natural gas in mixture with air is thus pulled from the tank into the combustion chamber. The combustion chamber consists of two glass tubes, one open and one closed. Each of these tubes contains a wire filament heated by electrical current. The tubes are coupled thus in a balanced bridge circuit. The filament in the open tube has a definite electrical resistance and when an air/gas mixture is pulled into the combustion chamber, the gas ignites, raising the temperature of the wire filament in the open tube and thereby increasing its electrical resistance. The variation in resistance between the two filaments, due to the ignition of gas, disturbs the electrical balance of the bridge circuit. This in turn causes a loud horn to blow thereby notifying the observer and the drilling crew that a gas-bearing formation has been encountered. An e.m.f. of 2 volts is maintained on the circuit.

The point at which the horn will blow can be regulated by a "pre-selector," which is in the form of a manually operated dial set on the left side of the combustion chamber. This dial is graduated in units from 0 to 100. It was found, during the course of drilling the Vaughn well, that best results could be obtained by setting the pre-selector dial 3 points below the point at which the horn would blow. By following this procedure, any blowing of the horn would be indicative of an appreciable quantity of gas in the mud, and would eliminate from the record the small quantities of gas that were being continually liberated from some of the shale beds. The sensitivity of the apparatus is such that 1 percent and more of gas by volume may be readily recognized.

Although the gas detector gives only

a qualitative determination of the presence of gas in the mud some quantitative idea of gas volume may be obtained by the number of units that the pre-selector dial must be turned back in order to stop the horn from blowing. A small amount of gas in the mud will only require a few units on the pre-selector dial whereas greater quantities of gas will require a larger number of pre-selector units. It was generally observed while a gas-bearing sand was being drilled that the pre-selector dial frequently required reverse adjustment until the maximum point of gas concentration in the mud was reached. Beyond this point, as the gas content of the mud decreased, the pre-selector dial would be moved forward until the normal position was reached, indicating that the gas-bearing formation had been mudded off. As an example of this procedure the gas detector record is given in Table 13 for the time during which the Vaughn sand was being drilled.

Some regulation of the sensitivity of the gas detector can be accomplished by varying the intensity of the suction on the separator tank. While the Second and Third Sands were being drilled the amount of gas in the mud was so large that even with the application of the smallest vacuum possible the horn would still blow when the pre-selector dial had been set back to zero, and the apparatus was therefore shutdown.

There is, of course, a considerable lag between the time that the bit actually penetrates a gas-bearing formation and the time that the gas-cut mud comes to the surface, and its presence indicated by the detector. It is necessary, therefore, to keep a timed record of the rate of drilling and also a timed record of the performance of the detector in order to calculate the depth of the well from which the gas actually originates. Continuous records of this nature will further indicate the presence of a series of gas-bearing sands and the speed of mudding action along the walls of the hole. The following formulas may be used for this purpose, and it may be applied in similar manner for the calculation of the depth of origin of mud samples for the determination of oil content by the fluoroscope.

$$T = \frac{A}{Q}$$

where

T = the time in minutes required for the mud to come from the bottom of the hole at the time the horn blows

A = the annular space in cu. ft. between the drill pipe and wall of the hole at the time the horn blows, and is calculated by multiplying the total depth at the time the horn blows by the annular volume in cu. ft. for a length of one ft.

Q = the number of cu. ft. of mud displaced by the pump per minute.

$$F = \frac{T}{DS}$$

where

F = the ft. of lag at the average rate of drilling as calculated from the time log

DS = the average drilling speed in min. per ft. taken from the time log.

$$D' = D - F$$

where

D′ = the depth of origin

D = the depth of the well at the time the horn blows. It would naturally follow that D′ can be determined by subtracting F from D.

TABLE 13

Gas detector record for the Vaughn Sand

Time	Depth	Change in pre-selector dial	Units on pre-selector to shut-off blow
A.M.			
12:15	8445	3	From 54 to 51
12:42	8447	3	From 54 to 51
2:35	8454	3	From 54 to 51
3:50*	8459	3	From 51 to 48
5:00	8463.8	3	From 48 to 45
5:20	8463.5	3	From 45 to 42
5:25	8463.7	3	From 42 to 39
5:30	8464	3	From 39 to 36
5:38	8464†	1	From 36 to 35
5:42	8464†	1	From 35 to 34
6:25	8464†	1	From 34 to 33
8:00	8469	15‡	From 33 to 48

*Beginning of downward movement of pre-selector.
†Circulating mud.
‡Pre-selector returning to normal position.
Normal point on pre-selector to shut-off blow—51.
Total points change on pre-selector—21.
Gas-bearing sand calculated from around 8450 to 8460 ft.

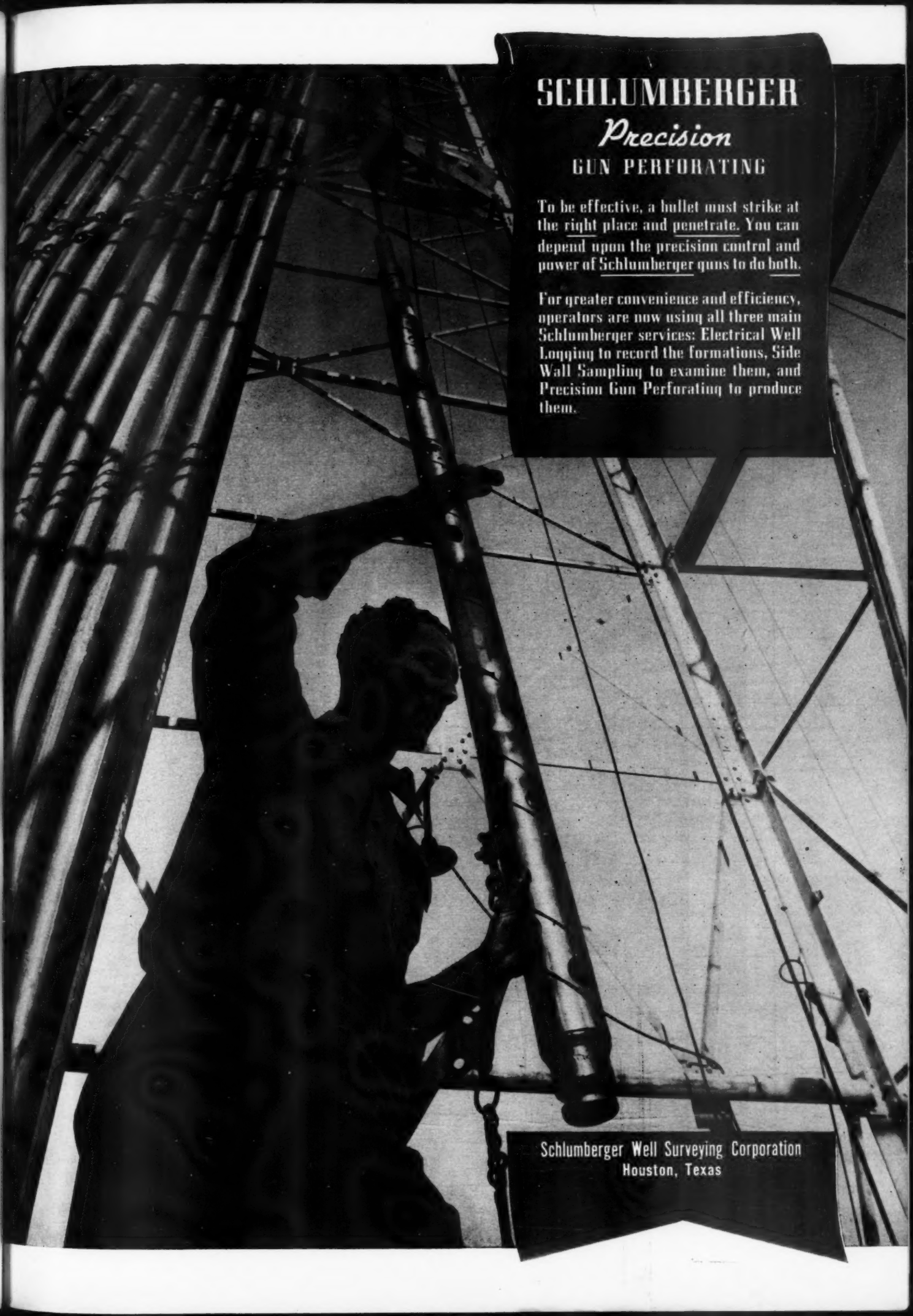
The gas detector proved to be most valuable in the drilling of the well, not only in the accurate prediction of the presence of gas-bearing sands, but also in the elimination of unnecessary coring. Whenever the time log indicated that a porous sand had been encountered, drilling would be discontinued and the mud circulated for a sufficient time to permit the mud from the bottom of the hole to come to the surface. If the formation was shown to be gas-bearing, the drill pipe would then be pulled from the hole and the core barrel put on in order to obtain a core of the formation. If no gas was evident in the mud, drilling was immediately resumed, thereby saving from 6 to 12 hours, depending on the depth of the hole, required to take a core. This procedure was followed five or six times with entirely satisfactory results, and it is estimated that the saving in time and in core-cutter heads more than equaled the rental cost of the gas detector. The accuracy of the predictions of the gas detector was amply confirmed by the electrical log and by actual production tests.

8. Electrical logging. Three separate electrical surveys were made of the Vaughn well. The first survey was made from 5285 to 6982 ft. depths to provide information that might be used for purposes of correlation with the electrical log of the Brownfield well in the Sugar Creek field. The second survey, made from 6900 to 8503 ft. depths, gave a record of the electrical properties of the First Sand and the Vaughn Sand. The third survey was made from 8420 to 8895 ft. depths. The third survey gave a second record of the Vaughn sand and also a record of the Second and Third Sands. It is interesting to note that the self-potential of the Vaughn Sand is somewhat higher in the record of the third survey than in that of the second survey.

From a study of the various electrical surveys made in the Vaughn well it was predicted, before any production tests were made, that the First Sand would carry water, that the Vaughn Sand would carry gas and possibly some light oil, and that the Second and Third Sands would be gas-bearing. It was pointed out, however, that the permeability of the Second and Third Sands was probably quite low, and that in consequence their productive capacity would be quite limited. These predictions, when production tests were made, conformed very closely to the record of the gas detector and to the core analyses.

No particular difficulty was encountered in making the electrical surveys except for the slight sticking of the electrode while it was being pulled by the Second Sand due to the formation of a heavy filter cake at this point. The mud was thoroughly circulated from the bottom of the hole upward before each survey was made; pumping continued until no more drill cuttings came over the shale shaker.

9. Time logging. A time log was kept of every foot of formation drilled during the course of deepening the Vaughn well. The time log record has been graphically plotted in Fig. 7, using the same vertical scale as that of the records of the electrical surveys (2 in. = 100 ft.), thus making it possible to obtain a direct correlation between the two different records. The horizontal scale of the time log is 25 min. per in., and the graph is plotted as the average rate of penetration in min. per ft. for intervals of 5 ft. In addition to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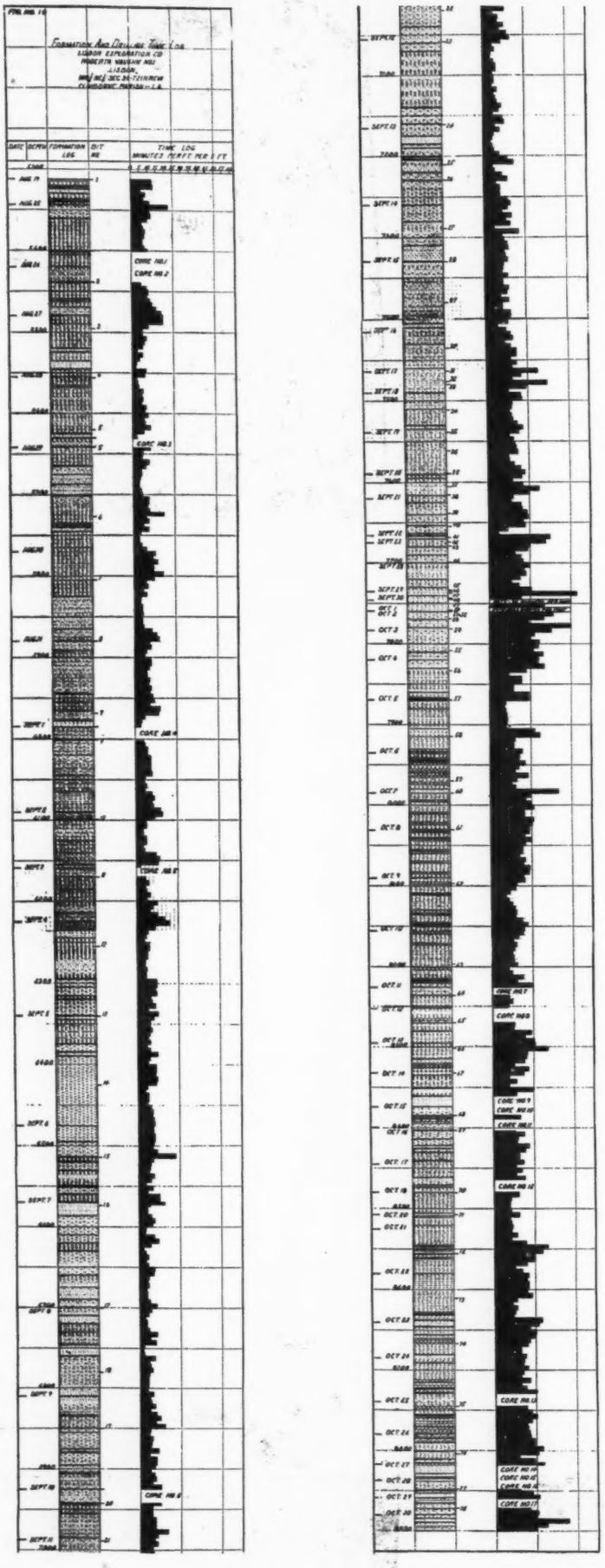


Fig. 7. Formation and drilling time log—Roberta Vaughn No. 1

the time log, the record gives a graphic representation of the formations encountered. It also shows where each core was taken, where each bit was put on, and the footage drilled each day.

The keeping of an accurate time log has proved to be well worthwhile. As previously stated, this record is essential for the proper interpretation of the gas detector record. In addition it will prove to be most useful for purposes of correlation with other deep wells that may be drilled in the area, and it has proved to be of great value in the study of bit performance, which will be discussed later.

The rate of penetration was timed in 5-ft. intervals, the kelly being marked with chalk at the measured points. The footage intervals were kept as closely to figures evenly divisible by five as possible, and all fractional overlaps as each joint of pipe went down were taken into consideration when a succeeding joint was added. In addition to timing the rate of penetration, a complete record was kept for each 5-ft. interval, of the average rotating speed, the number of strokes per minute of the mud pump (which provided the basis for the calculation of mud displacement in the hole), and the weight carried on the bit. All shutdown time also was recorded and, as will be shown in following sections of the report, this information has enabled the suggestion of a procedure that should materially improve the efficiency of future deep drilling in the area, and make possible a substantial reduction in drilling costs. As is generally customary, all coring was timed in 1-ft. intervals.

It will be readily recognized that the condition of the bit has a very important bearing on the rate of penetration. That is, a new bit with tight bearings will perform much better in a given type of formation than a dull-toothed bit with worn bearings. Furthermore, the type of bit used is most important. For instance one type of bit, designated here as "B", will perform very well in hard sands but not be effective in shales, whereas another type, "A", gives satisfactory service in shales and soft sands but is not effective in hard sands. Now that a complete formation record is available it should be possible to predict with considerable accuracy the horizons in which each type of bit should give more effective service. This study should reduce the number of bits required and at the same time increase

the average rate of penetration, thereby reducing the drilling time.

The time log indicates that in quite a few instances the time interval for the last 5 ft. of section, before an old bit was replaced with a new one, is greatly increased, notwithstanding the fact that there was apparently little change in the type of formation drilled. This is particularly evident in the upper part of the Travis Peak formation. Specific examples may be cited as follows: bit No. 6 at 5728 ft.; bit No. 7 at 5805 ft.; bit No. 10 at 6098 ft.; bit No. 15 at 6513 ft., etc.

It was noted that the marked reduction in the rate of penetration was due as much to excessive bearing wear, resulting in a pronounced drag of the bit, as it was to wear of the teeth of the cones. Generally speaking, as long as the bearings remain in good condition the bit will continue to make hole at a good average rate of speed until the teeth are practically worn down. When this point is reached the bit will refuse to drill-off, and by a careful observation of the weight indicator the driller can easily recognize that it is time to pull the drill pipe and put on a fresh bit. Bit replacements required primarily by the wearing down of the cone teeth therefore do not make such significant breaks in the time log. Examples of this condition are quite common in the lower part of the Travis Peak formation where new bits did not materially increase the rate of penetration of the preceding worn bits.

The rate of penetration in the shales of the Cotton Valley formation appears to be extraordinarily slow. This is in part due to the "B" type of bits used in this section not being suitable to the sands encountered, which were, at the time, not known. As will be pointed out later this is also in part due to the reduced displacement capacity of the mud pumps at the depth at which the shales were encountered. These shales drill-up into coarse fragments, and undoubtedly if more powerful pumps were available to lift the drilled-up material to the top of the hole the rate of penetration would be materially increased.

10. Study of rate of penetration and bit performance. Rate of penetration and bit performance in rotary drilling are affected by table speed, mud fluid volume, weight on the bit, and the character of the formations drilled. Of equal importance is the efficiency of the rig, and the experience and ability of the drillers and their assistants.

Increased rate of penetration will reduce the total time required to drill a well, and better bit performance will also reduce the drilling time owing to fewer trips required for the replacement of worn bits, and in addition will diminish the bit bill, thereby reducing the total cost of drilling. In connection with the continuous time log kept on the Vaughn well the history of each bit was recorded carefully together with other pertinent factors such as rotary table speed and mud fluid volume. These data have been graphically plotted and are given in Fig. 8.

In connection with the study of bit performance it should be stated that much better results may be anticipated in future deep-drilling operations in the Lisbon field owing to the fact that it is now possible to suggest types of bits that are designed especially for the formations that will be encountered. In the drilling of the Vaughn well it was impossible to predict this in advance, and in consequence thereof, on several occasions bits were employed that were not designed to drill efficiently the rocks encountered after a fresh bit was run into the hole. Eliminating, for the time being, all other factors involved in the performance of bits the accompanying schedule (Table 14) has been prepared to indicate the adaptibility of bits of various design to different types of rocks, and it is suggested that this may be used to advantage in future deep drilling in the Lisbon field.

Table 14 indicates that impressive savings can be realized from the proper selection of bits to conform to the character of the formations encountered. It will, of course, be recognized that the depth record, taken from the Vaughn well, may not correspond exactly with that which may be found in other deep wells that may be drilled in the field, but any such variations that may occur can be established readily by comparison of time logs and proper corrections can then be made.

From the experience gained in deepening the Vaughn well, one particular type of bit, "A", will perform well in soft sands, limestones, and hard shales. The cone teeth are stronger and the space between the teeth less than in bits designed for softer formations. The teeth in this type of bit are interlocking thus providing for self-cleaning, whereas those in the other type of bit, "B", used in the work do not interlock. For this reason the latter is not adapted to the drilling of shales. The cone teeth of the "B" bit are faced with an extremely hard alloy and are closely spaced with long tooth crests. The cones are not beveled and they run in an approximately true rolling position thus minimizing wear. Another type bit, not used but believed suitable, resembles the "A" bit in the number and arrangement of the cone teeth, but the alloy facing of the teeth is much heavier and corresponds quite closely to the facing used on the "B" bit.

In Fig. 8 the type of bit used, bit penetration, average penetration in minutes per foot, rotary speed, pump fluid volume, type of formation drilled by each bit, and relative hardness of formation have been graphically plotted for each bit in a manner permitting a direct comparison of bit performance under all conditions encountered during the course of drilling the Vaughn well. The various mechanical factors that have a bearing on the rate of penetration will be individually considered.

(a) Rotating speed. Referring to Fig. 8 it will be noted that while using the "A" type of bit, where the rotating speed was in excess of 80 r.p.m., the average rate of penetration was about 10 min. per ft.; when the rotating speed varied from 50 to 80 r.p.m., however, the average rate of penetration was about 20 min. per ft.

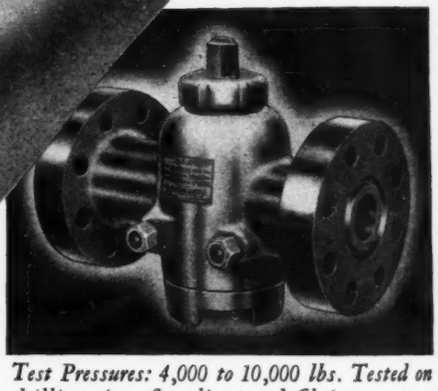
TABLE 14

Suggested bit program for deep wells in the Lisbon field

Depth below Pettit, ft.	Type of bit	Total footage	No. of bits	Avg. depth, per bit, ft.	Time saved in trips over Vaughn well	No. of bits saved over Vaughn well
0–2137	"A"	2137	30	71	0	0
2137–2422	"B"	285	9	32	26.5 hr.	5
2422–2467	"C"	45	6	7.5	15.9 hr.	3
2467–2517	"B"	50	2	25	0	0
2517–2667	"A"	150	3	50	0	0
2667–2672	"C"	5	1	5	0	0
2672–2907	"A"	235	3	78.3	0	0
2907–3037	"B"	130	4	32.5	0	0
3037–3069	Core	32	....	....		
3069–3099	"B"	30	1	30	0	0
3099–3133	"A"	34	1	34	0	0
3133–3151	Core	18	....	....		
3151–3322	"A"	171	4	42.7	0	0
3322–3352	"B"	30	1	30	0	0
3352–3502	"A"	150	3	50	0	0
3502–3547	Core	45	....	....	5.3 hr.	1
3547–3587	"B"	40	1	40	0	0
	Total.....	3587	69		47.7 hr.	9

Summary:

Number of "A" bits suggested, 44.
Number of "B" bits suggested, 18.
Number of "C" bits suggested, 7.
Number of cores saved, 9 (see section on coring).
Number of bits saved over Vaughn well, 9.
Time saved in trips over vaughn well, 47.7 hr.



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The Cylindrical Core Prevents Wedging. This enables the Mission valve to operate more easily than the old-style valve with a tapered plug. Wear is reduced and leakage is checked because a perfect seal can be constantly maintained as the straight plug always fits its seat perfectly.

Automatic Lubrication Assures a Perfect Seal. Mission, exclusively, uses line pressure to force the sealing lubricant from storage reservoirs to grease grooves which completely encircle each port opening. This constant pressure assures a perfect seal as long as a supply of grease is maintained in the reservoirs. This system adds indefinitely to the life of the valve and makes operation easier as well.

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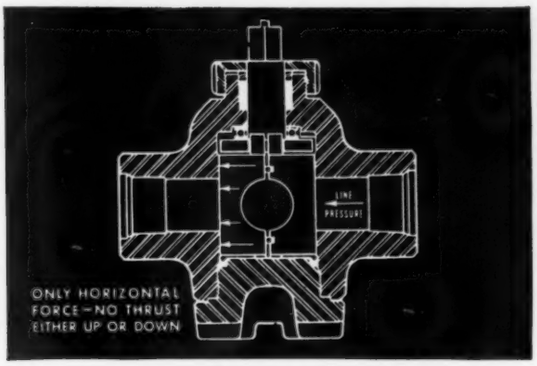
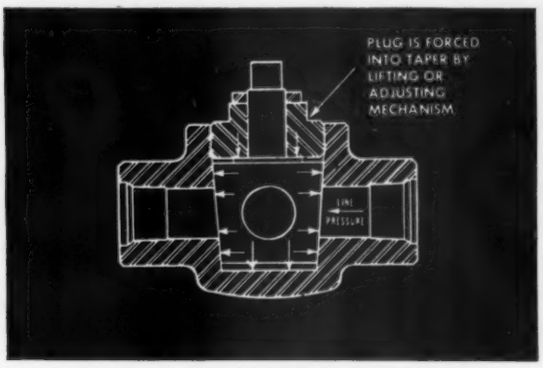


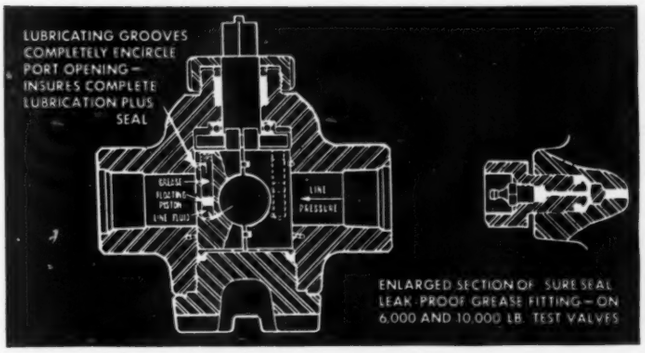
MISSION STRAIGHT CORE

A cylindrical plug seats perfectly and permits minimum side wall clearance. Constant lubricating seal is easily maintained. This increases valve life—assures easy operation.



CONVENTIONAL TAPERED PLUG

A tapered plug also has vertical motion. It can seat perfectly only when wedged. Greater side wall clearance in operation makes a perfect seal difficult and allows opportunity for sand to accumulate under the seat. This increases friction and wear.


LUBRICATING GROOVES COMPLETELY ENCIRCLE PORT OPENING—INSURES COMPLETE LUBRICATION PLUS SEAL
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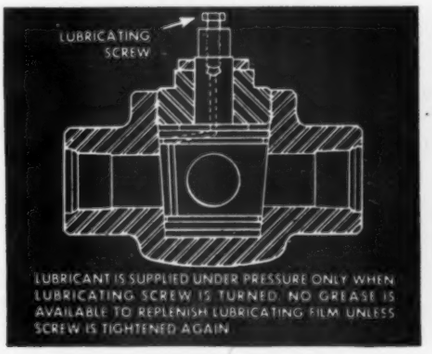
FLOATING PISTON
LINE PRESSURE
ENLARGED SECTION OF SURE SEAL LEAK PROOF GREASE FITTING—ON 6,000 AND 10,000 LB. TEST VALVES

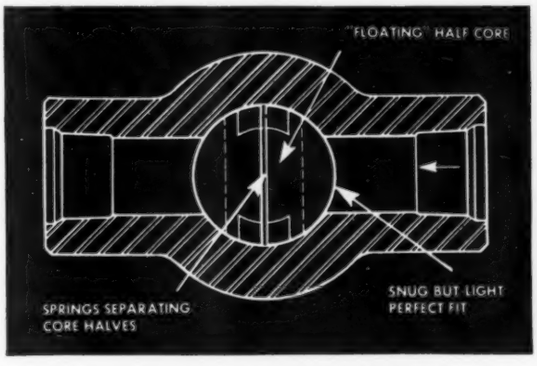
MISSION AUTOMATIC "FULL-PORT" LUBRICATION

Line pressure against piston in lubricating storage reservoir automatically forces and holds sufficient lubricant in place in the grease grooves to both lubricate and form a perfect seal at all times regardless of pressure.


LUBRICATING SCREW
LUBRICANT IS SUPPLIED UNDER PRESSURE ONLY WHEN LUBRICATING SCREW IS TURNED. NO GREASE IS AVAILABLE TO REPLENISH LUBRICATING FILM UNLESS SCREW IS TIGHTENED AGAIN

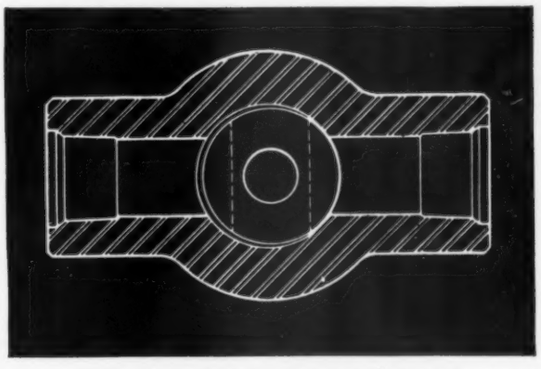
CONVENTIONAL LUBRICATION

Lack of constant pressure to replenish the lubricating film as rapidly as necessary can quickly cause serious damage and leakage.



MISSION SPLIT CORE

Perfect contact with body allows instant seal under pressure. This protects surfaces from sand and grit, reduces cutting and wear, and reduces maintenance costs.



CONVENTIONAL SOLID PLUG

Unless wedged, a solid plug cannot fit its seat perfectly. As the plug wears, it cannot fit. This permits accumulation of sand and grit, accelerating wear, and greatly increases difficulty of operation.

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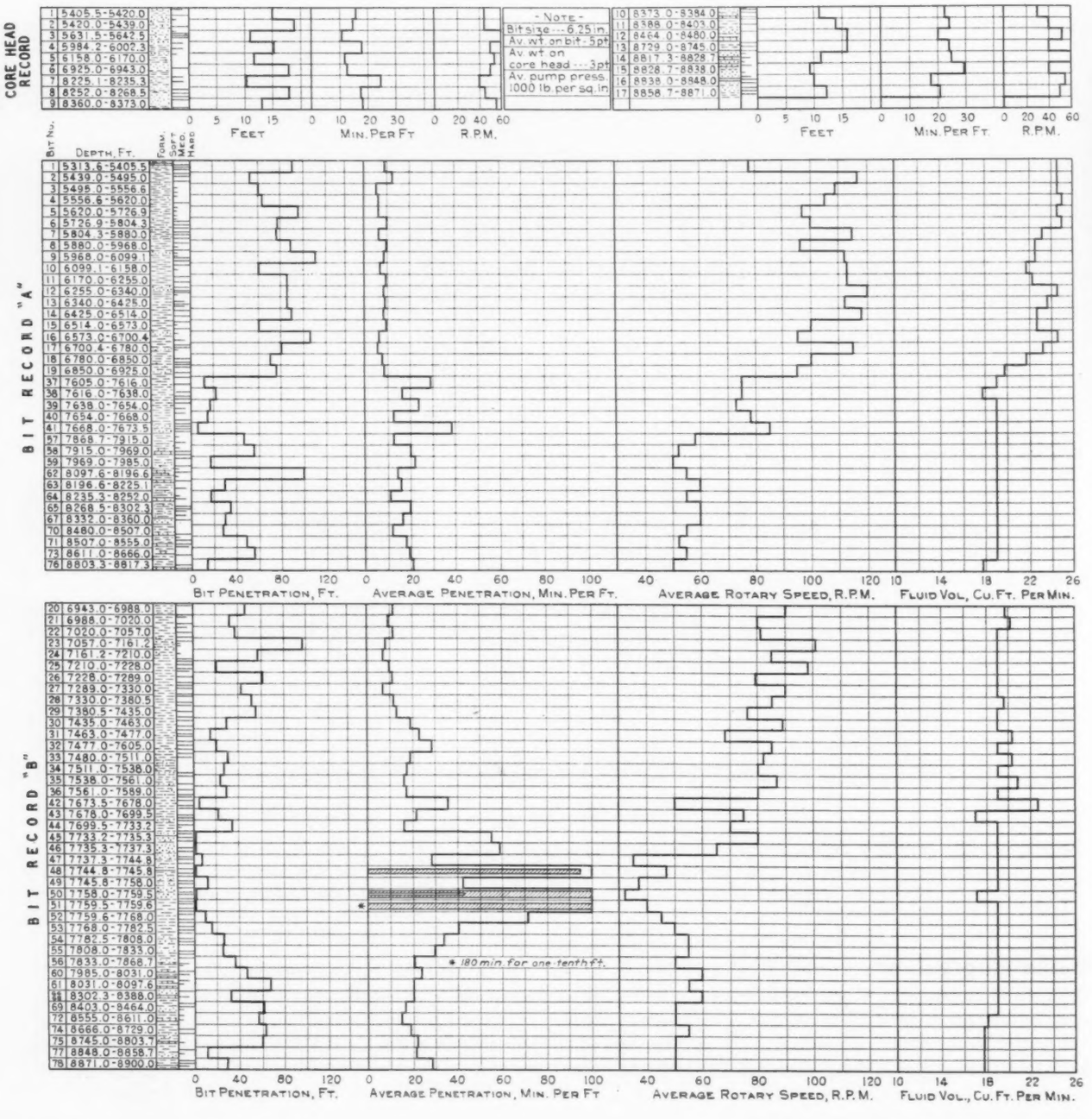
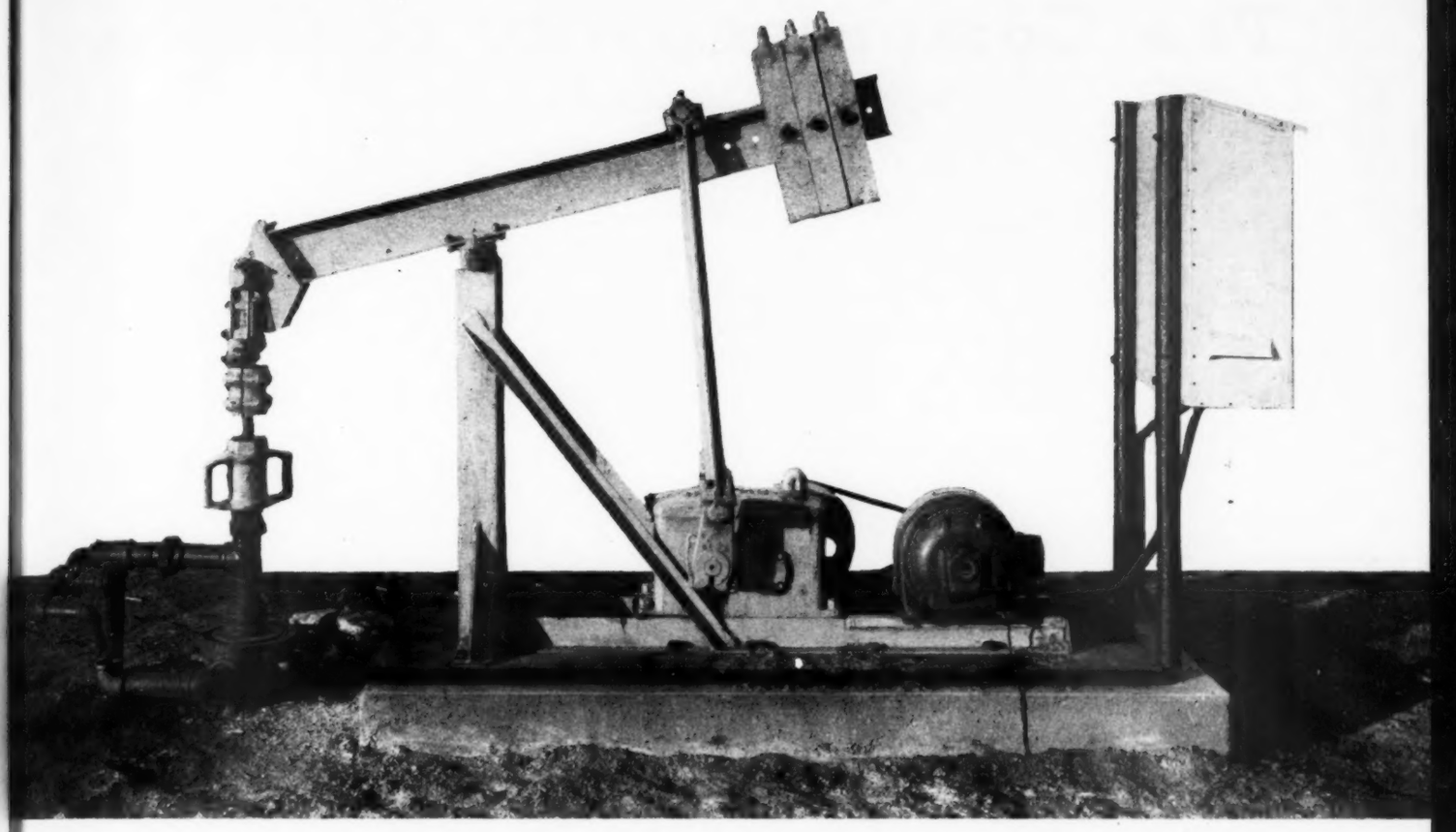
This would indicate that a maintenance of high rotary speeds should increase materially the rate of penetration over that expected at slower speeds.

The correlation between rate of penetration and rotary speed where the "B" type of bit was used is not so definite owing to the fact that this type of bit was used in the drilling of several shale sections where it could not perform effectively. Then, too, the drilling of the extremely hard, quartzitic sand sections presented unusual problems of penetration, and it will be noted that in these beds the rate of penetration showed a marked decrease when the rotary speed averaged about 40 r.p.m. Taking into consideration the small size of the bits and the light weight of the drill pipe it is doubtful whether the rotary speed, while these hard beds were being drilled, could have been increased materially without danger of a twist-off. In other horizons an average rotating speed of 85 r.p.m. gave an average rate of penetration of about 10 min. per ft.; an average rotating speed of 70 r.p.m. gave an average rate of penetration of about 20 min. per ft., and an average rotating speed of 55 r.p.m. gave an average rate of penetration of about 25 min. per ft. At the lower average rotating speed of 55 r.p.m. the "B" type bits were drilling principally in shale causing a pronounced drag of the cones that placed an unusual load on the drilling engine resulting in slower rotation and a consequent reduced rate of penetration. It may, however, be concluded very definitely that the rate of penetration increases in almost direct proportion to increased rotary speed under normal drilling conditions; based, of course, on performance in formations adapted to the use of the "B" type bit.

EDITOR'S NOTE: This article will be continued in an early issue.

Fig. 8. Bit record and drilling data





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P 213.3
P 687.

The Compressibility of Gases

IV. Methods of Approximation

By GEORGE GRANGER BROWN

Professor of Chemical Engineering, University of Michigan

Two errors that appeared in the March issue should be corrected at this time. Equation (17) as printed on page 28 should read as follows:

$$-\int_1^2 VdP = \frac{n(P_1V_1 - P_2V_2)}{n-1} = \frac{nP_1V_1\left[1-\left(\frac{P_2}{P_1}\right)^{\frac{n-1}{n}}\right]}{n-1} = \frac{u_2^2 - u_1^2}{2g} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (17)$$

On page 29 (March issue), part of a paragraph was omitted. Consequently, the text between equation (24) and the next following equation should read as follows:

St. cu. ft. per hr. =

$$C\sqrt{\frac{(h_1 - h_2)_w P_2}{Z}} \quad . \quad . \quad . \quad (24)$$

If the meter coefficient is so expressed (equation 24), the value for Z is frequently assumed to be equal to unity, as for ideal gases. It is necessary to include the correct value for Z, or multiply the meter reading calculated by the ideal gas law by $\sqrt{\frac{1}{Z}}$. To obtain a correct value for Z it is clear from the previous discussion that an accurate reading for the temperature of the gas being measured is as important as an accurate reading for the pressure. Because a difference of 15° between the gas temperature and the standard temperature introduces less than 3 percent error in the meter reading when assuming the ideal gas laws, the importance of an accurate temperature reading is frequently overlooked even in measurements at high pressure. This practice is unfortunate, as the temperature is most important in determining values for Z, particularly at high pressure.

The independent correction for the temperature of the gas being measured should also be made. This can be done by multiplying by:

$$\sqrt{\frac{T_s}{T}} = \sqrt{\frac{460 + t_s\,°F.}{460 + t\,°F.}}$$

The Relationship Between Z and "n"

THE USE of the compressibility factor, Z, was explained as a correction factor to the ideal gas laws in making calculations involving gases under pressure. A different way of doing the same thing is outlined in a Bureau of Minues publication[1] in connection with a factor, n, called the percent deviation from ideal gas. This percent deviation from ideal gas was to be determined experimentally as:

$$n = 100\left(\frac{\frac{RT}{MP} - V}{V}\right) \quad . \quad . \quad (27)$$

where

$\frac{RT}{MP}$ = specific volume at T and P as computed by the ideal gas equation

V = measured specific volume at T and P.

$$V(100+n) = 100\,\frac{RT}{MP}$$

$$PV = \left(\frac{100}{100+n}\right)\frac{RT}{M} = \left(\frac{100}{100+n}\right)NRT$$

$$PV = ZNRT \quad . \quad . \quad . \quad . \quad (4)$$

$$Z = \frac{100}{100+n} \quad . \quad . \quad . \quad (28a)$$

$$\frac{1}{Z} = \frac{100+n}{100} = 1 + \frac{n}{100} \quad (28b)$$

$$n = \frac{100}{Z} - 100 \quad . \quad . \quad . \quad . \quad . \quad (29)$$

Although the compressibility factor, Z, is a more convenient factor to use than the so-called percent deviation from ideal gas, it is clear that the two are mutually convertible and therefore interchangeable, as in the relationship given by equation (29). Values for n may be determined, therefore, from values of Z, obtained from Fig. 4 in the manner described in the second installment, by means of equation (29). As the values for Z so determined are accurate within 1 percent, accurate values for n may be computed in this manner from the composition of gas without the necessity of experimental measurement.

A Convenient Approximation

Frequently the gas composition is not readily available and some more convenient relationship would be useful even at a sacrifice in accuracy. In Fig. 8 is plotted the pseudo-critical pressure in lb. per sq. in. absolute as a function of the specific gravity of the gas (referred to air as 1.0) as regularly determined at atmospheric temperature and pressure. The points represent all the available data on natural gases, and clearly indicate a smooth curve from which the pseudo-critical pressure of a natural gas may be estimated within close limits from the observed gravity.

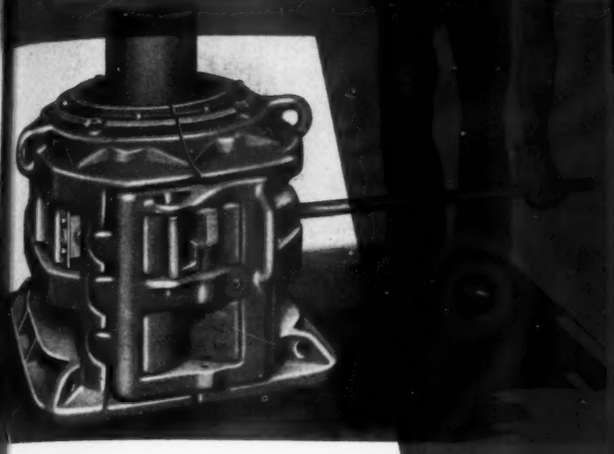
Fig. 9 is a similar plot of the absolute pseudo-critical temperature as a function of the specific gravity of the gas. With a few exceptions the points fall on a smooth curve that may be used to estimate the pseudo-critical temperature of a natural gas from its

GEO. GRANGER BROWN

obtained the bachelor's degree in chemical engineering from New York University in 1917—Post graduate studies, while serving as a member of the faculty in the Department of Chemical Engineering, University of Michigan, led to the doctor's degree, received in 1924—A year later, in 1925, the professional degree of chemical engineer was granted by New York University—During the period 1917-20, Brown served variously with the Aluminum Company of America, Massens, New York, the Chemical Warfare Service, Washington, D. C., and with the Youngstown Sheet and Tube Company, Evanston, Illinois—During the period 1920-24, concurrently with his studies leading to a Ph.D., Brown served with the Michigan Geological Survey as special investigator for clays, shales, and sand—He is now professor of chemical engineering in the University of Michigan and is a member of the American Institute of Chemical Engineers, the American Petroleum Institute, the Society of Automotive Engineers, the American Society for Testing Materials, the American Chemical Society, and was awarded the William H. Walker Award for 1939 for meritorious contributions to chemical engineering literature—Although his work has taken him into many branches of the chemical industry, he has always kept up active work in the petroleum industry, particularly concerning the properties of natural gasoline and its constituent hydrocarbons.

[1] "Deviation of Natural Gas From Boyle's Law," by T. W. Johnson and W. B. Berwald, U. S. Bureau of Mines Technical Paper 539.

REMEMBER—



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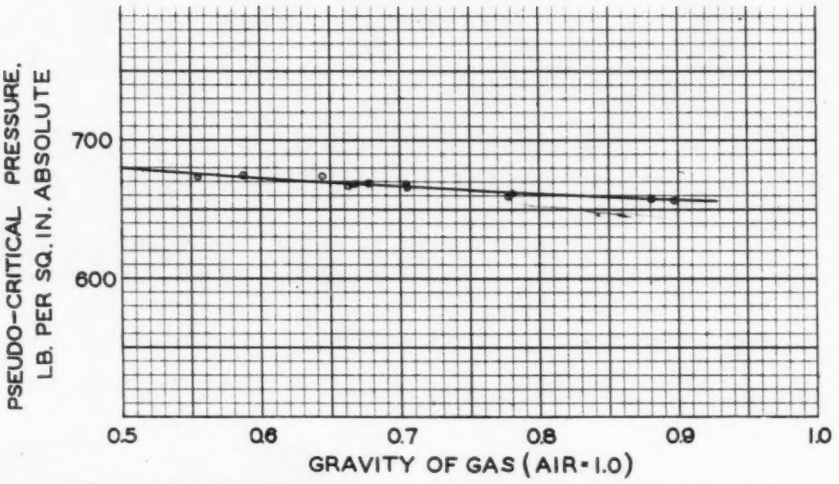


Fig. 8. Pseudo-critical pressure plotted against gravity of gas

specific gravity (referred to air as 1.0). Although agreement with the curve is not so good for the pseudo-critical temperature in Fig. 9 as for the pseudo-critical pressure in Fig. 8, the relationship may be used when an accurate analysis is not available.

If the gas from a single source is analyzed over a period of time, curves such as those given in Figs. 8 and 9 may be determined, which should give the pseudo-critical temperature and pressure of gas from that source as a function of specific gravity with a high degree of precision. In Figs. 8 and 9, gases from many fields and different sources have been combined in an effort to find a relationship that might be of universal application. Although Figs. 8 and 9 are probably entirely satisfactory for most conditions, the possibility of increased error should be recognized in their use.

Calculating Gas Formation Pressure

In determining the pressure in the producing formation, or at the bottom of a gas well, from the shut-in equilibrium casinghead pressure, it is necessary to know the density of the gas in the well. In many cases the gas has been assumed to follow the ideal gas laws with results that may be in considerable error.

Reference to Fig. 9 indicates that the pseudo-critical temperature for most natural gases is approximately 375° absolute, so that the pseudo-reduced temperature of such a gas when in a well would vary from about 1.4 to 1.6 corresponding to temperatures from 60°F. to 140°F. Similarly from Fig. 8, if the absolute pressure is between 1200 and 3300 lb. per sq. in., the pseudo-reduced pressure would be between 2 and 5. Over these ranges of reduced temperature and pressure, the value for Z as indicated in Fig. 4 is reasonably constant for any reduced temperature so that a single value for Z taken at the average temperature and pressure of the gas in the well may be used as the correction factor to correct the density calculations for deviations from the ideal gas laws.

For example, compute the bottom-hole or formation pressure, from the following data:

Specific gravity of gas (air = 1) 0.680
Molecular wt. = 28.9* × 0.68 = 19.7
Shut-in casinghead pressure . . . . . 1900 lb. per sq. in. abs.
Casinghead elevation above sea . . . . . 4100 ft.
Depth of well (2200 ft. subsea) . . . . . 6300 ft.
Average temperature . . . . . 80°F. (540° abs.)

Computations:

Pseudo-critical pressure from Fig. 8 . . 668 lb. per sq. in. abs.
Pseudo-critical temperature from Fig. 9 . . . . . 380° abs.

*28.9 = mol. wt. of air.

TABLE 5

Sample calculation of gas reserves beginning July 1, 1940

Line No.						
1	Date	7/1/40	9/10/40	7/1/41	9/1/41	12/30/41
2	Specific gravity of gas	0.68		0.68		0.68
3	Pseudo-critical pressure (Fig. 8 or from analysis), lb. per sq. in. abs	668		668		668
4	Pseudo-critical temperature (Fig. 9 or from analysis), °abs	380		380		380
5	Total gas production from reservoir in billions std. cu. ft. at 14.65 lb. per sq. in. and 60°F.	0	256	560	653	740
6	Reservoir pressure, P, lb. per sq. in. abs. (measured, or calculated from shut-in casinghead pressure as described)	2000	1500	1000	802	660
7	Reservoir temperature, T, °F	110	110	110	110	110
8	Pseudo-reduced pressure in reservoir, Pr	2.99	2.25	1.50	1.20	0.988
9	Pseudo-reduced temperature in reservoir, Tr	1.5	1.5	1.5	1.5	1.5
10	Compressibility, Z, at reservoir conditions	0.778	0.810	0.860	0.880	0.910
11	Std. cu. ft. of gas in 1 cu. ft. of pore space in reservoir $\frac{379 \times P}{ZRT} = 0.062 \frac{P}{Z}$	159.4	114.5	72.0	56.5	45.0
12	Std. cu. ft. of gas released from 1 cu. ft. of pore space since first measurement	.....	44.9	87.4	102.9	114.4
13	Calculated billions cu. ft. of pore space to produce total gas production since first measurement	.....	5.7	6.4	6.35	6.47
14	Calculated initial reserve at 2000 lb. per sq. in. reservoir pressure or first measurement in billions of std. cu. ft. (159.4 x pore space)	.....	910	1020	1010	1030
15	Current reserve in billions of std. cu. ft.	.....	654	460	357	290

Footnote to line 11

The volume of 1 lb.-molecular wt. of an ideal gas at standard conditions (60°F. and 14.65 lb. per sq. in. abs.) is 379 cu. ft. The number of standard cu. ft. of gas, therefore, in one cu. ft. of pore space in the reservoir will be 379 divided by the volume of 1 lb.-molecular wt. at the conditions of temperature and pressure existing in the reservoir. The volume of 1 lb.-molecular wt. under reservoir conditions is:

$$V = \frac{ZRT}{P} = RT\left(\frac{Z}{P}\right) = 10.71 \times 570\left(\frac{Z}{P}\right) = 6100\left(\frac{Z}{P}\right)$$

The number of std. cu. ft. in 1 cu. ft. of pore space is, therefore:

$$379 \times \frac{P}{ZRT} = \frac{379}{6100} \cdot \frac{P}{Z} = 0.062 \frac{P}{Z}$$

Footnote to line 12

The values in line 12 are obtained by subtracting the values in line 11 from the original value of line 11, namely, 159.4.

Footnote to line 13

The values in line 13 are obtained by dividing the values of line 12 into the values of line 5.

Footnote to line 14

Values in line 15 are obtained by subtracting values in line 5 from line 14. 11, namely, 159.4.

Footnote to line 15

Values in line 15 are obtained by subtracting line 5 from 14.

Pseudo-reduced temperature

$$\text{at } 80°\text{F.} = \frac{460 + 80}{380} = 1.42$$

Pseudo-reduced pressure at 1900 lb. per sq. in. abs. $= \frac{1900}{668} = 2.84.$

Z at $T_r = 1.42$ and $P_r = 2.84$ from Fig. 4 . . . . . 0.725

As the pressure increases, the value for Z decreases very slightly (less than 1 percent) and the value of 0.725 may be used as an average value for the entire depth.

The increase in pressure, from casinghead to bottom of hole in lb. per sq. in., equals the density of the gas in lb. per cu. ft. for conditions of average temperature and pressure between casinghead and bottom, times depth in ft., divided by 144.

Let ΔP = pressure at bottom minus pressure at casinghead.

$$\text{Density} = \frac{1}{V} = \frac{P}{ZNRT} = \frac{1900 + \frac{\Delta P}{2}}{0.725 \times \frac{1}{19.7} \times 10.71 \times 540}$$

$$= 0.00474\left(1900 + \frac{\Delta P}{2}\right)$$

$$\Delta P = \frac{\text{density} \times \text{depth}}{144} = \frac{0.00474\left(1900 + \frac{\Delta P}{2}\right) 6300}{144}.$$

$$\Delta P = 0.208\left(1900 + \frac{\Delta P}{2}\right)$$

$$= 395 + 0.104\,\Delta P.$$

$\Delta P = 441$ lb. per sq. in.

The bottom-hole pressure is, therefore, 1900 + 441 or 2341 lb. per sq. in. absolute.

The method just outlined has been checked against numerous measurements of bottom-hole pressures in gas wells and found to agree closely in all cases.

Calculating Gas Reserves

If the quantity of gas produced over definite time intervals is known, and the formation pressure can be computed at the beginning and end of each time interval, the gas reserves and the pressure drop accompanying further production may be calculated with satisfactory accuracy by the relationships already presented.

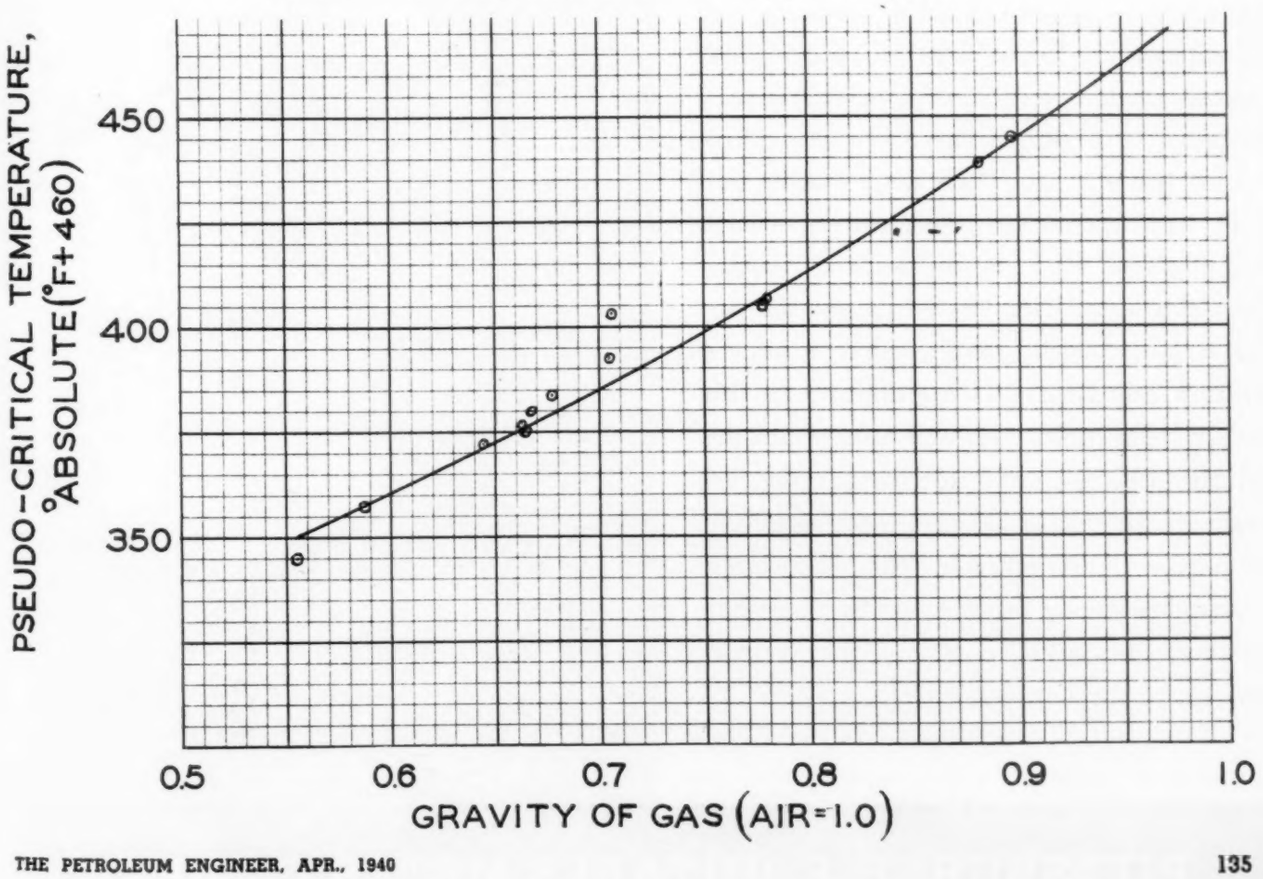
The data tabulated in Table 5 will make clear the application of these relationships to the calculation of gas reserves whether the data begin with the original tapping of the reservoir or at some later period.

If the true formation pressure is used in the calculations as outlined in Table 5, the calculated reserve will be accurate. But in many cases where the permeability of the formation is low, the bottom-hole pressure as measured or calculated from shut-in casinghead pressure is less than the correct equilibrium pressure of the formation, unless the well is shut-in for some time.

If the pressure used in the calculation, line 6, is low, the calculated std. cu. ft. of gas in 1 cu. ft. of pore space, line 11, is proportionately low. This results in a low value for pore space and a low value for the calculated reserve. It is important, therefore, to be sure that the formation pressure used in such calculations is the true equilibrium pressure that is attained after the gas in the formation is in equilibrium with the gas in the bottom of the hole.

The accuracy and convenience of the compressibility factor makes calculations of gases at high pressures as accurate and almost as simple as the use of the ideal gas laws at low pressures. Having the relationships of Figs. 8 and 9, only the specific gravity of the gas, or its molecular weight, is required for the satisfactory use of the compressibility factor. This is no more information than is required for the application of the simple ideal gas laws.

Fig. 9. Pseudo-critical temperature plotted against gravity of gas



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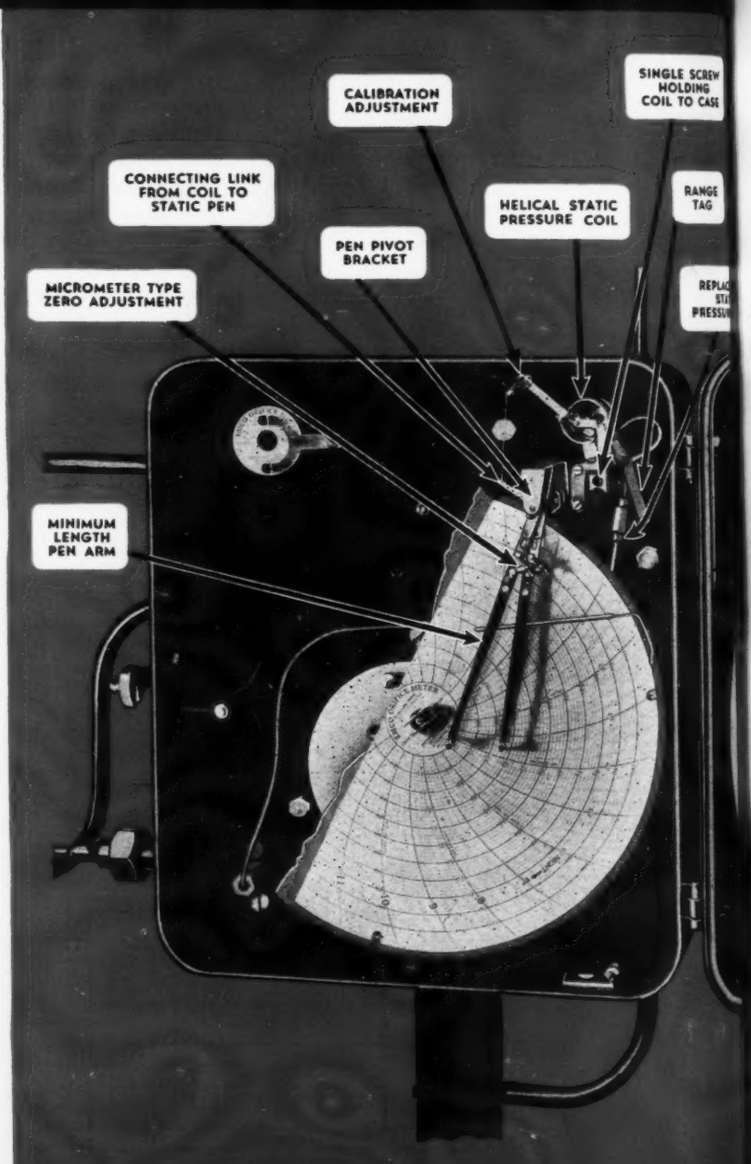
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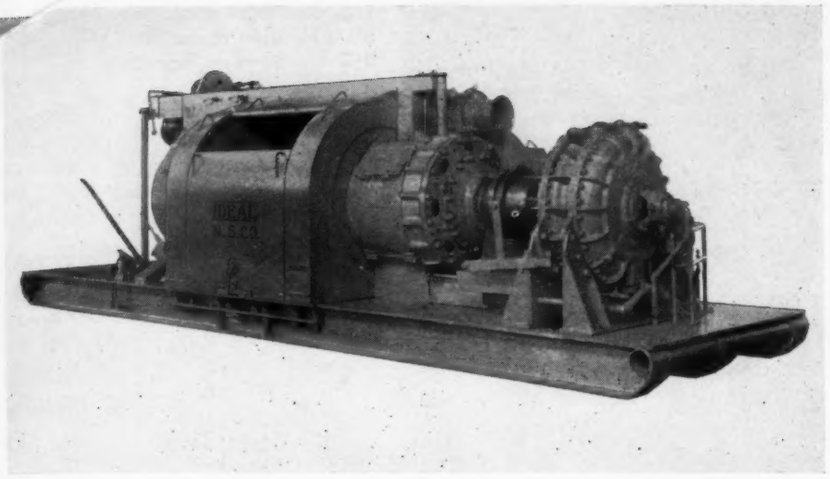

Fig. 1. General view of main drawworks

By
WALLACE A. SAWDON
Pacific Coast and Foreign Editor

Rotary Super-Rig of Advanced Design Is Largest In Operation

It anticipates the heaviest duty demands likely to be encountered in deep drilling for some time to come, is steam-driven, has largest drawworks yet built, and a combination standby drawworks and rotary table driven by one engine

WHAT is unquestionably the largest well-drilling plant ever assembled has recently been installed by Superior Oil Company for drilling its Weber No. 2 well in the Rio Bravo field, California. In addition to using 500-lb. steam and some of the largest and heaviest equipment yet employed for rotary operations, this new rig includes the largest drawworks ever built and introduces a combined rotary drive and standby unit of advanced design. The other surface equipment, steam generating plant, and pumps are similar to those described in previous articles[1] but with the installation of the new drawworks and combined rotary drive and standby unit, the original "super-rig" objective of the company has been realized. There is no doubt about the equipment being adequate for efficient drilling to any depths conceived as possible at the present time; in the meanwhile, fast completions to the 11,500-ft. depths in the Rio Bravo field will be accomplished with maximum facility.

The new drawworks is shown in Fig. 1. This drawworks has three shafts, three speeds, and an air-operated friction clutch on the high drive to the drumshaft. Together with a 40-in. double rotor hydromatic brake, it is mounted as a single unit on a skid-type unitized frame having an overall length of 28 ft. It is driven by a 15 by 14 twin-cylinder engine of the piston-valve type equipped with roller bearings and having a built-in chain guard. This engine is operated with 500-lb. steam. The chain drive from engine to drawworks consists of two 3⅛-in. pitch double chains. Cascade lubrication is used with all sprockets, clutches, and bearings, which are enclosed in oil-tight housings.

Although the drawworks has a total of three speeds, there are only two chain drives to the drumshaft. When handling drill pipe only two speeds are used—a multiple jaw clutch low speed and an air-operated multiple disk-type friction clutch high speed. A compound low speed obtained by means of a novel drive involving the jackshaft and lineshaft provides for handling casing or for pulling on a stuck drill-pipe string. The high-speed and low-speed drives to drumshaft are each two double 3⅛-in. pitch chains and the compound drive of jackshaft to lineshaft to jackshaft is one double 3⅛-in. pitch chain. There are no clutch keyways on the jackshaft or drumshaft, these having been eliminated by means of gear tooth members rigidly mounted to drive the sliding clutches. No rotary drive is provided and when this drawworks is used some other power must be used to drive the rotary machine. This adds to the compactness of the design.

The drum is 32 in. in diameter by 57⅞ in. long and is grooved for 1¼-in. line. This provides for spooling 1080 ft. of 1¼-in. line in less than three layers and requires but two rises of the line. The 1080-ft. length is

[1] "Large Drilling Equipment Tested on Two Wells in California," *The Petroleum Engineer*, August, 1939, and "Heavy Duty Surface Equipment for Deep Drilling Being Tested in California," *The Petroleum Engineer*, March, 1939, both by Wallace A. Sawdon.

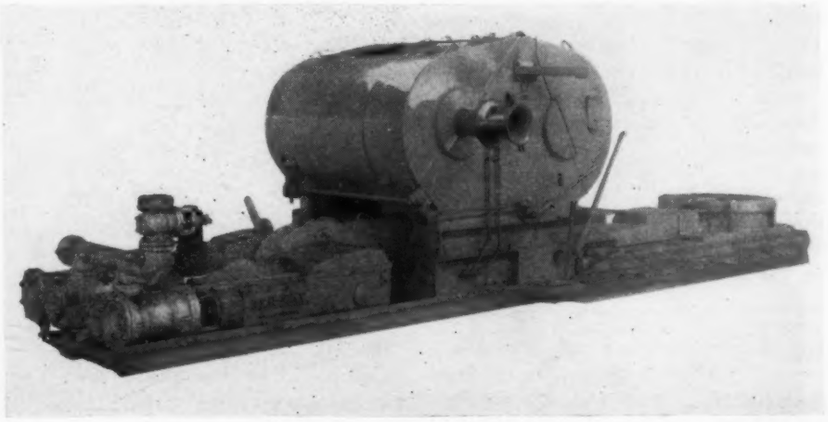

Fig. 2. Combined standby drawworks and rotary table driven by one engine

Fig. 3. Steam at 500-lb. pressu used to drive these two 15½ by 9½ by 20 slush pumps

control water regulator for hydromatic brake circulation, disengaging gear tooth coupling attachment to hydromatic brake, catline hoist and standard high-speed automatic cathead with foot-operated controls, long roller-bearing rope roller on driller's end and short roller-bearing rope roller on far end, and front drum, brake rim, and rear shaft guards.

The entire unit is provided with diamond tread steel flooring. The assembly weighs 80,000 lb. and was shipped on a flat car via railroad. It was transported from the flat car to the well site on a tractor-drawn trailer supported by two axles, each of which had four rubber-tired wheels on each end, a total of 16 wheels carrying the load. Unloading of the drawworks began on a Monday morning and the well was spudded-in on the following Friday morning.

The combined rotary drive and standby unit is the latest design of horizontal twin steam engine drive for powering the rotary machine. It is set on the derrick floor as illustrated in accompanying photographs and the one engine driving both the rotary machine and the standby hoist thus eliminates the engine placed below the derrick floor, which, on the other super-rig installations, powered the rotary table alone. Moreover, the 20½-in. rotary machine is operated by a gear drive and not through chains as was the case in the underfloor rotary drive.

The assembled rotary drive and standby unit with sand reel, rotary machine, and engine is shown in Fig. 2. This assembly is made-up of two units

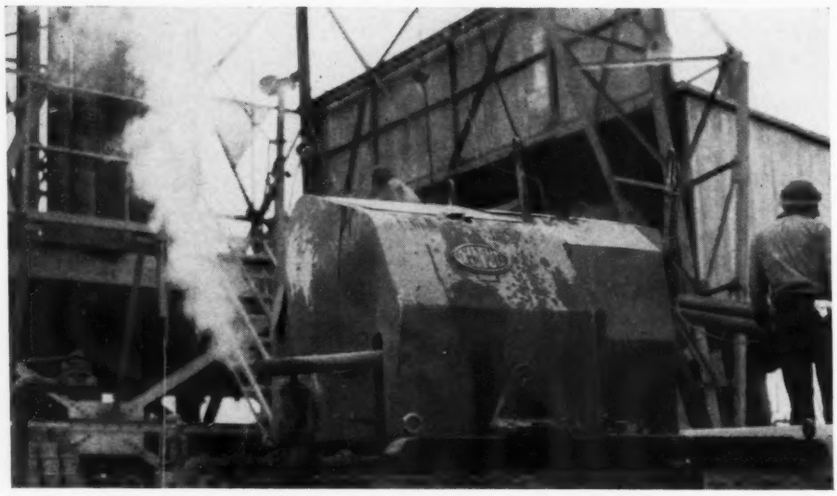

Fig. 4. Well deviation is checked by a wire-line drift recorder operated by this hoist

ample for 8 lines in the 176-ft. derrick that is being used for drilling this well. The combination low and second speed drive through a multiple jaw clutch has a gear tooth spline drive to the drum. The drumshaft is of 11¾ in. nominal diameter and 15 ft. 4½ in. long. The brake rims are 62 in. by 10⅜ in. and are water-cooled. The brake leverage ratio is 73 to 1.

Compressed air for operation of the drawworks friction clutch is supplied by an 8 by 8 by 10 steam-driven air compressor operating on 150-lb. steam and situated below the derrick floor at the end of the drawworks engine substructure. Other auxiliary equipment on the drawworks includes a pressure

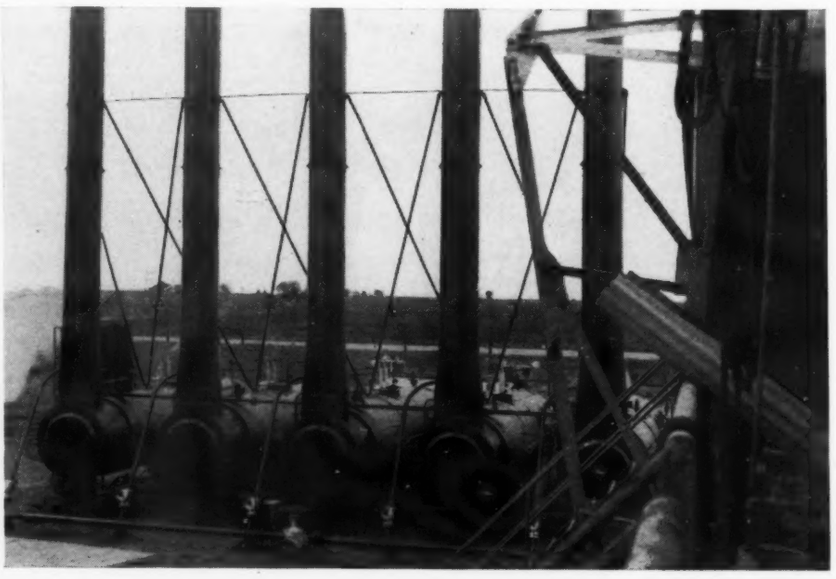

Fig. 5. Five boilers supply steam at 500-lb. pressure for drilling operations

Fig. 6. Going back in the hole after a trip to change bits. The enclosed rotary-table drive can be seen in front of the standby drawworks

—the engine and standby hoist unit and the rotary machine and driveshaft unit. The 12 by 12 piston-valve-type twin-cylinder steam engine is operated by 350-lb. steam. The drive from a 26-tooth engine sprocket to a power transmission shaft is through a 3⅛-in. pitch double chain. Driving of the rotary machine is by an extended shaft from a beveled gear on the power transmission shaft. This driveshaft is connected to the rotary machine by a floating shaft with a gear-type flexible coupling at each end. A sprocket is proved on the pinionshaft of the rotary machine between the flexible coupling and outboard bearing and is used for drilling the rat hole.

The sand-reel shaft, which is also a catshaft, is chain driven from the power transmission shaft and the drumshaft in turn is chain driven from the sand-reel shaft. A plain cathead is on one end of the sand-reel shaft and an extended type cathead is on the other end or operating side of the machine. This extended cathead is used for spinning-up the drill pipe and is placed to give complete visibility and unobstructed passageway between the cathead and the hole. The standby drum with two 54-in. rims has a capacity of 3500 ft. of 1¼-in. line and the sand reel a capacity of 15,000 ft. of 9/16-in. line. The overall width of the unit is 8 ft.

By remote control, the standby unit, as well as the drawworks, is operated from the driller's position. The standby unit, of course, can be operated at the standby position. A pneumatic power reverse unit is assembled on the rotary drive and standby engine and pneumatic reverse control is from both positions. A hydraulic throttle control provides steam control of the rotary and standby engine from the driller's position. When a standby hoist is not desired, the rotary drive assembly alone can be used.

The steam generating plant consists of five domeless 500-lb. steam pressure boilers with a rated capacity of 130 hp. and with super-heaters built integrally in the units. Fuel gas and air to the burners are automatically controlled. The three feedwater pumps are 10 by 6¼ by 10 and are mounted as a unit on one base with two 10-kw. turbo generators. The 500-lb. steam is used for operation of the 15 by 14 drawworks engine, the large mud pumps, the feedwater pumps, and the turbo generators. As the 12 by 12 rotary drive and standby engine and the 14 by 7½ by 14 mud-mixing pump operate on 350-lb. steam, a pressure-reducing regulator on a special steam line to these units reduces the steam pressure from 500 lb. to 350 lb.

Two 15½ by 9¼ by 22 slush pumps are used for circulating the drilling fluid. These pumps are still the largest being employed for rotary-drilling operation and, using 500-lb. steam at a speed of 60 s.p.m., have a displacement of 1450 gal. per min. each. The suction connection is 10 in., discharge pipe connection 3½ in., steam inlet 4 in., and steam exhaust 6 in.

The other equipment being used is the same as described in the previous articles[1] mentioned above. Practically all the equipment is of the largest and heaviest types available. Rotating speeds to 450 r.p.m. are contemplated with this rig but faster rotation may be used on future wells.

One week after the well was spudded-in, a depth of approximately 6700 ft. had been reached with 12¾-in. surface string run and cemented. After setting the surface string the well was equipped with a full-closing cellar control gate above which was placed a blowout preventer. The well will probably be drilled to a depth of about 11,500 ft. Completion (including running and comenting 7⅝-in. casing, and running 5¾-in. liner and 2½-in. tubing) is expected in less than 40 days.

Fig. 7. Drill pipe incorporating the new integral tool joint was used in drilling the well

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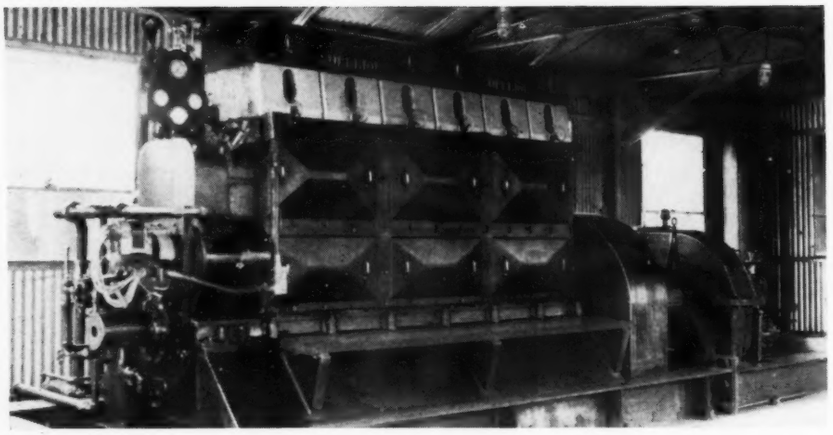


Engine driving centrifugal pump in station at Kadane Corner, Wichita County, Texas

PETROLEUM ENGINEER EXCLUSIVE FEATURE

By
J. C. ALBRIGHT

Pump Station on Oil Pipe Line Designed for Ready Dismantling

THE first demand upon a pipe line station handling crude oil is the uninterrupted delivery of the material being pumped. To insure continuous delivery of oil from the station, the equipment should be fitted with apparatus that will guard against shutdowns due to any preventable reason. To attain a high salvage value, provision should be made whereby the engines, pumps, and auxiliary equipment can be dismantled and shipped with the least amount of trouble and delay. Many of these features have been incorporated in the design of the pipeline station of Sinclair Prairie Pipe Line Company, just north of Kadane Corner, in the K.M.A. field, Wichita County, Texas.

The station was built to pump K.M.A. crude oil through the pipe line system that connects with Sinclair's trunk line in Jack County. It is situated near the banks of Beaver Creek. The site was selected so that most of the oil passing through the field gathering system will flow by gravity to the steel storage tanks at the pump station.

A 600-r.p.m., 9-in. bore by 12-in. stroke, six cylinder, vertical gas engine was installed as the power unit, coupled through a geared speed increaser to a multistage centrifugal pipeline pump. The pump has a capacity of 350 gal. per min. at a speed of 3600 r.p.m. against a head of 1975 ft. All three units may be considered as a single unit, as they are mounted on a substantial I-beam sub-foundation.

Instead of building foundation forms to provide a raised concrete block, well above the pump-room floor as in most installations, the foundation was finished almost flush with the floor level. Standard foundation bolts were placed so that they would extend through holes in the I-beam subfoundation instead of through the bases of the three units. The I-beam base was supplied in two sections, flanged together so that all units are in alignment as soon as the flange bolts are tightened.

The engine cooling system is a closed circuit, with the water passing through a more or less conventional heat exchanger. The water first flows through the shell-and-tube lubricating-oil cooler before it enters the jackets of the cylinders. The lubricating oil is thus cooled from a crankcase temperature of 120°F. to about 80°F. The oil used in the geared speed increaser is also cooled in a small shell-and-tube exchanger, to maintain a relatively low temperature in the gear case of that unit. Water is also circulated through the pump-shaft packing-gland coolers to reduce the temperature of the unit.

The lubricating oil is drained frequently from the crank case of the engine and the gear case of the speed increaser, and treated to remove foreign matter, such as particles of bearing metal and sludge that may have accumulated while the machines are in operation. The oil is washed with hot water, which is circulated from the base of the oil reclamation vessel through a jacket on the exhaust pipe of the engine, and back to the oil reclamation vessel. A small rotary pump powered by a 1-hp. electric motor is used to circulate the water, and a similar unit is installed beside the first to pump the oil from the receiving tank to the reclamation vessel, and to an overhead supply tank from which the oil flows by gravity to the service taps.

The I-beam foundation described, was used so that, if necessity arises, all that is required to move the units is to remove the nuts from the foundation bolts, unflange the pipe lines, and uncouple the foundation I-beam. Practically all of the station lines are installed in a concrete-lined, grating-covered trench, so that all equipment may be moved except the foundation block and pump-room floor.

J. C. ALBRIGHT

was drilling superintendent for H. J. von Hagen in North Texas area, 1919-1921—With the Noble Oil and Gas Company, Burkburnett, Texas, from 1921 to 1923—Joined staff of the Dixie Gasoline Company in 1923 and became Texas manager—Employed by Phillips Petroleum Company in 1925 and was sent to New Mexico where the company constructed a natural gasoline plant—Left Phillips in 1929 and for a time operated as a consulting engineer—For last ten years has devoted virtually all his time to free-lance writing for trade journals.

Compact, Efficient Equipment In New Gasoline Plant

Liquid and vapor pressures force liquid products through the processing equipment in Waskom, Texas, gasoline plant. Two-coil, direct-fired preheater furnace is innovation in gasoline-plant design

By
D. N. BARROW, Plant Superintendent
and
DON ATTAWAY, Arkansas Fuel Oil Company

BEGINNING construction on December 26, 1939, the Arkansas Fuel Oil Company completed erection of the Waskom gasoline plant on February 28, 1940—an elapsed time of 65 days required for construction, even when handicapped, as it was, by rains, extreme cold, and wind.

The plant is situated on a 20-acre tract about 1 mile southwest of Waskom, Texas, and is partly visible from U. S. Highway 80 passing about ¾ mile due north of the plant. The plant has several unusual features that are of interest.

Gas is gathered from five company-owned wells within a 5-mi. radius of the plant by three 4-in., one 8-in., and one 2-in. line. These lines converge at the plant site. The gas passes through a header into a high-pressure separator, thence through two absorbers, and is discharged into the 16-in. main gathering line of the distribution department. The measuring equipment consists of two 8-in. inlet meter runs and two 8-in. outlet meter runs with two back-pressure control valves to regulate and maintain the desired pressure.

The absorber battery consists of two conventional, countercurrent, tray-type, vertical absorbers. One of these vessels is 40 in. in diameter by 30 ft. and the other is 36 in. by 30 ft. These absorbers are being operated at 350-lb. pressure at the present time.

Condensate trapped in the high-pressure inlet scrubber flows in the usual manner to a 6-ft. by 10-ft. distillate accumulator. Rich vapors from this vessel are charged into a 36-in. by 31-ft. reabsorber operating at about 45 lb. pressure, and stripped of their gasoline content, after which the dry gas is utilized as boiler fuel.

The distillate is then charged into a primary steam heater controlled by a recorder-controller instrument and thence to a 36-in. by 8-ft. gasoline flash tower. The enriched vapors from the latter tower then rise into a 5-ft. by 13-ft. reflux section of the gasoline still. The denuded distillate, controlled by a liquid-level control, flows into a charging line to a direct-fired preheater furnace having 60 horizontal tubes of which 12 in a separate section are set aside for heating the distillate as charging stock to a naphtha still.

The naphtha still is a 36-in. by 31-ft. vertical vessel that also receives a side stream charge from a 48-in. by 8-ft. naphtha flash tower into which the absorption oil from the stripping section of the gasoline still has been charged after being preheated through the remaining 48 tubes in the direct-fired preheater. A side cut from the naphtha still passes through a fabricated steam stripper, thence through a water-cooled condenser and into an accumulator, from which it emerges as a premium-grade kerosine.

The overhead from the naphtha still passes through a condenser and into an accumulator. Reflux for the unit is picked up from this accumulator by a 3 by 2 by 4 simplex pump. The finished naphtha is trapped to storage.

It is well to note in the condensate or raw distillate cycle that prime pressures are used as motive power and no pump is involved except for refluxing.

The absorption oil flow likewise makes full use of pressure differences. The enriched oil from the absorbers is trapped into the base of the reabsorber wherein the consequent drop in pressure from 350 lb. to 45 lb. allows the

DON ATTAWAY

began his career with the Dixie Gulf Gas Company as timekeeper in the Waskom district, January, 1928—Entered the payroll department of United Gas Company late in 1929 and worked there until he accepted a position with Arkansas Fuel Oil Company in September, 1930, in the gas accounting department—Worked successively as meter man, loading rack man, and utility man in the East Texas natural gasoline plant—Took an active part in the construction and operation of gasoline plants for the company.

D. N. BARROW

received his chemical engineering education at Louisiana State University and the Massachusetts Institute of Technology—Is a registered chemical engineer in the state of Texas and a member of the American Chemical Society—Prior to joining the Arkansas Fuel Oil Company in 1937, served as chemist, chief chemist, and in an engineering capacity in several Texas refineries.

vapors to flash and mix with the vapors of the raw distillate accumulator; the recoverable portions are absorbed by lean oil circulated over the reabsorber by a 6 by 4 by 6 pump. The oil then passes through one shell-and-tube heat exchanger, thence into a stream preheater, and to the top of a six-tray, 4-ft. by 13-ft. stripping section.

The lean oil from the base of this section is then charged into the 48-tube section of the direct-fired preheater and raised to a temperature of 380°F. prior to being charged into the naphtha flash drum. Vapors released in the drum rise to the side stream charge of the naphtha still as previously explained.

The denuded oil from the bottom of the naphtha flash drum is trapped-out and passes countercurrent to the cold rich oil through an exchanger and thence through a water-cooled condenser, thus decreasing the temperature to about 90°F., after which the oil is accumulated in an 8-ft. by 10-ft. vessel serving as a lean oil surge tank. Two 9 by 4½ by 10 duplex pumps take suction from this tank and start the oil through its cycle by discharging it into the high-pressure absorbers.

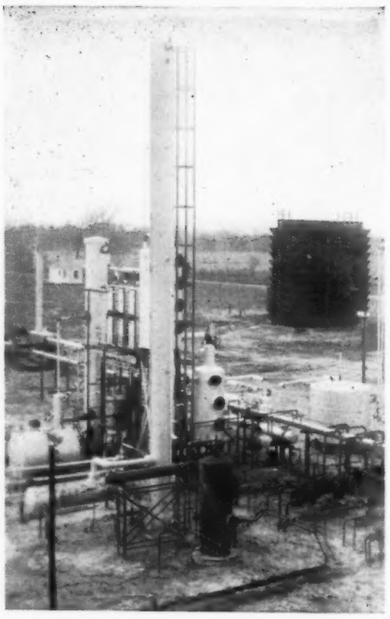
The gasoline distillate section is compactly and neatly arranged. Vapors from the still or stripping section ascend into a 5-ft. by 13-ft. vertical reflux section having 7 trays, and then pass into two enclosed, short-tube-type water-cooled condensers, thence through an aftercooler of the same type, and into a 6-ft. by 10-ft. raw gasoline accumulator. Vapors from the latter vessel are also utilized as plant fuel. Reflux is apportioned over the still by two 5½ by 3¾ by 7 pumps controlled by instrument.

The raw gasoline is then charged into a 30-tray stabilizer having a diameter of 18 in. and a height of 60 ft. This column operates at a pressure of 130 lb. A reboiler temperature of about 264°F. is maintained in order to manufacture a 14-lb. Reid product.

An interesting feature on the stabilizer is a 3-way valve to control reflux accumulator liquid level. By this automatic device, vapors may be bypassed around the reflux condenser when the level in the accumulator tends to become too high. Vapors from this accumulator are recovered for plant fuel.

The distillate accumulator is equipped with a liquid-level control valve that automatically traps raw distillate to storage when the level tends to become too high due to increased gas loads or to accumulations of condensate in the gathering lines being flooded into the high-pressure inlet scrubber.

The preheater furnace is an interesting installation due to the fact that two stocks are processed in separate coils within the furnace separated by a bridge wall of fire-brick. Temperatures on these two coils are maintained with separate burners, each controlled by its own instrument. The temperatures on the outlets of these two coils differ by about 100°F. This provision of dual temperatures within a single furnace may be customary in refinery practice, but it is believed an innovation in gasoline plant operation.



General view of Waskom gasoline plant

Water for plant use is supplied by two wells drilled to a depth of 90 ft., in which the water is lifted by the energy of residue gas obtained from the various plant vessels; after lifting the water, the gas may be utilized as plant fuel. An unusual feature of these wells is that they are equipped with special jets whereby the water may be lifted with a lower pressure and smaller volume of gas than in ordinary perforated tubing and casing installations.

The cooling tower is perhaps different from the usual structure in that it contains a drift eliminator. The structure is a 12-deck redwood louver-type tower, comprising five 6-ft. bays. The grids that distribute the water are placed at an angle of about 30° instead of the conventional horizontal style, which increases the efficiency of the tower and reduces wind loss.

Water for the plant is circulated by a 4 by 5 single stage centrifugal turbine-driven pump that pumps water to the condensers and coolers and back over the tower continuously. Boiler feedwater is taken from the hot discharge of various preheaters and condensers into an 8-ft. by 10-ft. tank and the cold make-up feedwater is controlled by an interesting float arrangement, fabricated in the field from a piece of equipment salvaged from a discarded "cheese-box" still vessel.

Steam is generated by a battery of four boilers. Three of the boilers are 85 hp. and the fourth is 125 hp. These boilers operate at 150-lb. pressure and are equipped with automatic fuel governors. The entire battery is housed in a 22-ft. by 40-ft. fabricated steel and sheet-iron building.

Electricity for plant lights is generated by two turbine-driven generators, one a 3 kw. and the other a 4 kw. in size. Practically all lighting is done by elevated flood-lights—a departure from usual plant lighting practices.

Modern safety equipment is installed throughout the plant including latest fire-fighting equipment as well as ample relief valves. The plant is equipped with an emergency manifold for a quick shutoff whereby all burners may be shut down from one central point at a safe distance. A relief valve installation ahead of the shutoff manifold vents vapors from vessels to a riser outside the plant yard.

Adequate standbys are provided for every pump on the plant, although no pumping is required in the oil circuits except for the lean oil over the absorbers. The pump battery is compactly arranged and conveniently situated.

Storage facilities consist of three 8-ft. by 30-ft. horizontal tanks for finished gasoline; one 8-ft. by 30-ft. horizontal tank for distillate storage; one 10-ft. by 30-ft. tank for kerosine storage; one 15-ft. by 20-ft. tank for naphtha storage; one 10-ft. by 22-ft. tank for absorption oil storage; one 10-ft. by 30-ft. tank for blending naphtha and natural gasoline for motor fuel, and one 8-ft. by 10-ft. vertical utility or work tank.

Plant production is pumped through two 2-in. welded lines to a four-car loading rack situated about three quarters of a mile north of the plant on the Texas and Pacific Railway. The loading pump is a 10 by 6 by 12 duplex pump equipped with a pressure governor automatic shutoff.

The plant has a capacity of 20,000,000 cu. ft. daily and an average gasoline yield of about 300 gal. per million cu. ft.

An attractive three-room office, 12 ft. by 24 ft., houses a well-equipped and complete laboratory, superintendent's office, and supply room. A direct telephone line provides communication with the main office at Shreveport, Louisiana.

This latest addition to the Arkansas Fuel Oil Company natural gasoline department increases the total number of plants to 11, situated at various points in Arkansas, Louisiana, and Texas.

X-Ray Method of Identifying Types of Scale-Forming Deposits

A PETROLEUM ENGINEER EXCLUSIVE FEATURE

Distinctive patterns of crystalline organic substances, when revealed by X-ray, aid the intelligent selection of scale-removal methods

By P. E. FITZGERALD
Dowell Incorporated

IT FREQUENTLY happens that the deposition of material from solution in heat exchangers, condensers, boilers, cooling radiators, turbine blades, cooling jackets, and other equipment with which heated fluids come in contact causes costly shutdowns and loss of machine efficiency. The deposition of scale, therefore, constitutes a major industrial problem and especially so as there is now a definite trend toward higher pressures, temperatures, and increased rates of evaporation.

This scale must be removed at regular intervals because not to do so may cause serious and costly delays in production schedules and a decline in machine efficiency.

The physical and chemical composition of these scales vary greatly, two of the greatest variables being thermal conductivity and acid solubility. The first of these is dependent upon the physical property of the scale and the latter upon its chemical composition.

Most scale deposits are soluble in inhibited hydrochloric acid to which has been added suitable auxiliary agents for increasing the solubility of the scale, controlling the surface tension of the acid and its reaction products, and increasing the preferential wettability of the scale by the acid.

The advantages of chemical scale removal are numerous and may be briefly listed as follows:

1. Removes scale thoroughly. (Old methods only 60-70 percent efficient.)
2. Shutdown time reduced as much as 90 percent.
3. No extra labor generally needed.
4. Solvents generally easy to apply —no unit dismantling necessary.
5. Subsequent deposits do not reform so quickly.
6. Tubes and other difficultly accessible areas are easy to clean chemically.

Power engineers have tried for a long time to use chemicals for scale removal. Some of these methods involved the use of raw corrosive hydrochloric acid, which was injurious to the equipment being cleaned, or acetic and sulphuric acids that do not do the work efficiently.

P. E. FITZGERALD

graduated from Ohio State University with a degree in geology—Work in the graduate school of the University of Michigan followed—Later was associated with the Ohio Cooperative Topographical Survey and with the Geological Department of the Pure Oil Company in Michigan —Joined the staff of Dowell Incorporated soon after its organization—Is a resident of Tulsa, Oklahoma.

With the development of improved technique and materials for treating scale-coated equipment, interest in chemical scale removal was revived and much of this type of work has been successfully and economically accomplished during the last few years.

Among the newer and more interesting developments in this field has been the use of X-rays to analyze quickly and cheaply the many types of scale that form in various vessels. This method permits a more rapid selection of the solvent best suited for the removal of the specific scale.

The X-ray method of analysis is founded upon the basic work of von Laue et al,[1] who learned that X-rays produce distinctive interference figures from crystals that are composed of space lattices of ions, atoms, or molecules and that these figures exhibit a characteristic type for each crystal.

In his original work on X-ray chemical analysis Hull[2] stated: "That every crystalline substance gives a pattern; that the same substance always gives the same pattern; and that in a mixture of substances each produces its pattern independently of the other, so that the photograph obtained of a mixture is the superimposed sum of photographs that would be obtained by exposing each of the components separately for the same length of time. This law applies quantitatively to the intensities of the lines as well as to their positions, so that the method is capable of development as a quantitative analysis."

The work of Hanawalt[3] and others in classifying the thousands of different chemical substances so that they may be easily used for the identification of an unknown, even if the unknown is a mixture of substances, has made the use of the Hull method of X-ray analysis of practical and valuable assistance to the chemist and engineer interested in a rapid and economical means of determining the definite identification of foreign compounds such as are encountered in industrial equipment as described in the first paragraph of this article.

The literature on X-ray applications describes many types of apparatus[4,5,6,7,8,9]. The type to be used depends upon the kind of data desired and the accuracy necessary. An X-ray laboratory capable of handling all techniques would require a large variety of apparatus. For the purpose of the chemical analysis discussed in this

article, however, much simpler and more economical apparatus will suffice.

According to Hanawalt, the multiple diffraction unit as described by Davey[10] is a convenient type. (Fig. 1). This unit consists of a transformer, X-ray tube with molybdenum target, and cameras. Twelve slits around the circumference of the cylinder containing the X-ray tube define the X-ray beams. There is also a switchboard on which are mounted the operating switches, meters, filament current stabilizer, a water pressure switch, and an overload circuit breaker. In addition to this standard equipment, Hanawalt uses a recording milliammeter, which gives a record of the tube current during exposure; a time switch, by which an exposure can be stopped at a predetermined time, and a temperature switch that cuts off the voltage when the cooling water temperature reaches 100°F.

The specimen tube is inserted in the camera at point "A" in Fig. 2; the film is placed in the rear of the camera at point "B", a distance of about 8 in. from the tube. A zirconium dioxide filter is placed in front of the film to absorb certain types of radiation and a fluorazure intensifying screen is placed directly behind the film. In order to obtain a more uniform pattern, the specimen tube is rotated during exposure by the motor shown at "C" in Fig. 2.

The specimens to be analyzed are loaded in powder form in a Pyrex capillary tube[11]. A plug of cotton is placed in the center of the tube and the samples loaded on either side of the cotton plug for a distance of 1 cm. After the samples are packed into the tube, another cotton plug is placed in each end of the tube, and the tube sealed in a flame.

After the specimen tube is loaded it is inserted in the camera at point "A" (Fig. 2). The assembly is then placed on the diffraction unit and exposed for 6 hours at 30,000 volts and 20 milliamperes. The unit described by Hanawalt and others holds 12 cameras; two specimens can be placed in each tube, thereby making possible the exposure of 24 specimens simultaneously. The development of all the films requires about one and one-half hours, and the time for analysis and recording, an additional half hour per specimen. By using a different type of camera, a pattern can be made in 15 minutes and a complete analysis in less than an hour. This method does not permit the simultaneous exposure of 24 specimens and, therefore, is not very practical except in rare instances.

It is well known that there are definite limitations to the field of application of the X-ray method of analysis, but there is no doubt of its value when used within its proper scope. The method is limited to solids and only to those solids that have a crystalline structure, or in other words, those solids that give a pattern. The only way to determine whether or not an unknown will give a pattern is to X-ray it. Experimental data indicate that about 5 percent of the solid inorganic chemical substances are amorphous and give no pattern.

Other substances give such weak patterns that, although they could be identified if they were the only constituents present, they might escape detection if mixed with something else. Also, appreciable percentages of elements may be present in solid solution without changing the pattern enough to be detected.

Certainty of analysis is one of the valuable features of the X-ray method but this certainty applies only to what the pattern shows.

If the exact percentages of the constituents composing the sample are not needed, as in the case of industrial scale analysis, the X-ray method will suffice. In some kinds of work, where it is necessary to know also the percentage of impurities that are present in small quantities, the combination of X-ray and spectroscopy is valuable as these two mediums give different information about the same substances. In the electric arc, the material is broken up into its elements, which are distinguishable, regardless of the state in which they are present. This is particularly applicable when it is desirable to identify elements present in small amounts. This differs from the X-ray, where the chemical and physical state of the more important compounds in the substances are recorded.

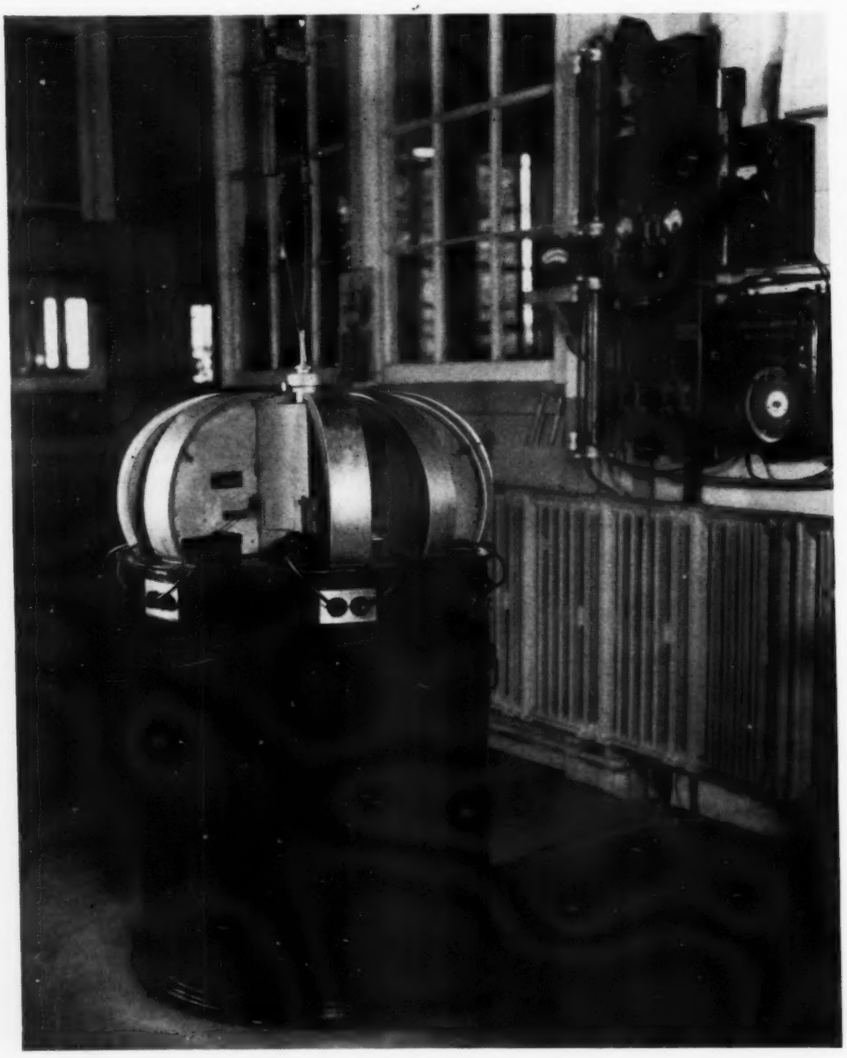
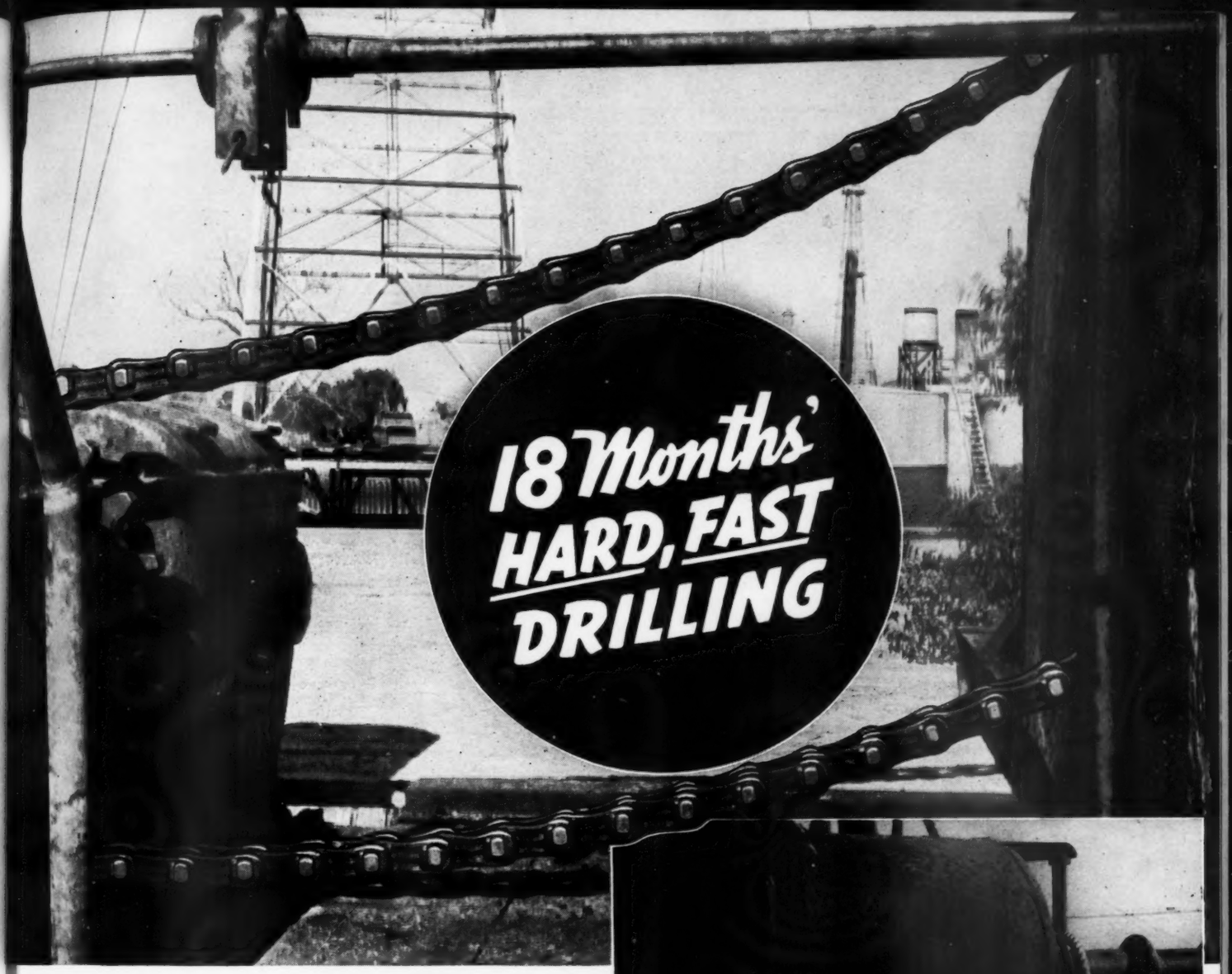


Fig. 1. The diffraction apparatus is so arranged that 24 X-ray exposures may be made simultaneously



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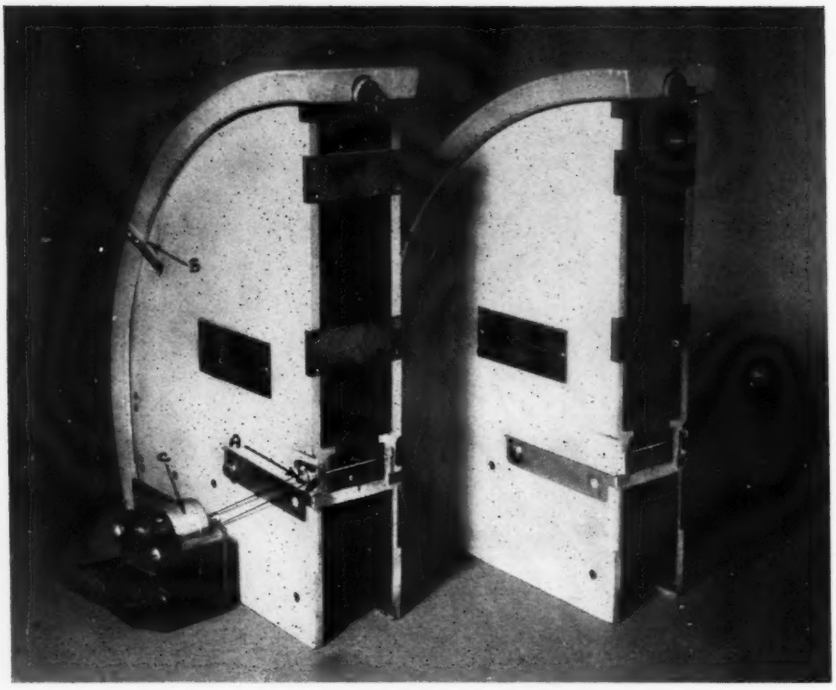

Fig. 2. Each cassette, or camera, of the X-ray diffraction apparatus is equipped with a small electric motor to turn the sample during exposure

Some of the advantages of the X-ray method of analysis are:

1. Substances are shown in their true state of chemical combination.
2. The analysis is conclusive, even though only small amounts of material are available. This is valuable for scale studies, where it is sometimes quite difficult to obtain a large sample without dismantling the vessel.
3. Samples are analyzed as received and are not destroyed.
4. Preparation of sample and procuring of the pattern are simple and economical.
5. A permanent record of data is always on file in the form of the pattern.
6. The analysis is quickly and cheaply made. This is of importance when time and expense is a controlling factor.

At the present time X-ray diffraction gives a semi-quantitative analysis. The accuracy varies widely but usually allows a determination to within 5 percent of the amount present.

An example of the type of patterns obtained by an X-ray analysis is shown in Fig. 3. Patterns A and B in this figure have been made from typical boiler scales. To determine the compounds present in these scale samples, it was only necessary to compare their X-ray patterns with standard patterns of pure compounds. The results of this comparison are shown by the chemical analysis in Fig. 3, A and B. More specifically the pattern for boiler scale A shows the dominant characteristics of the standard patterns for ∝ FeOOH, Fe_3O_4, and $FeCO_3$. Considering the intensity of the lines corresponding to these three standard patterns, it is estimated that the sample contains 40-50 percent ∝ FeOOH, 30-40 percent Fe_3O_4, and 10-20 percent $FeCO_3$. The analysis for boiler scale B was determined in a similar manner.

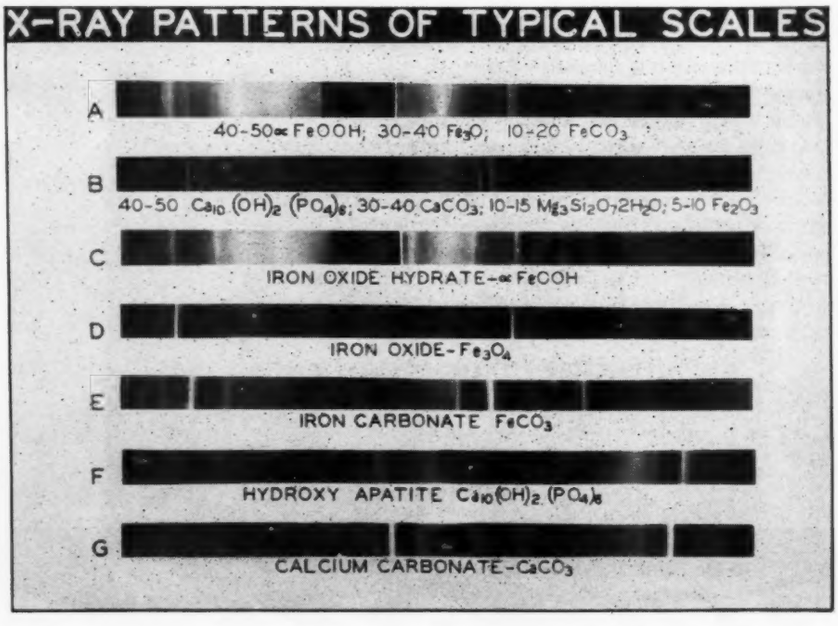

Fig. 3. Distinctive patterns of scale constituents aid in their identification

REFERENCES

[1]Interferenzerscheinungen von Rontgenstrahlen, by W. Knipping, P. Knipping, und m. von Laue, *Munchner Ber.*, S. 303, 1912; *Ann. der Phys., Bd.* 41, S. 917, 1913.

[2]A New Method of Chemical Analysis, by A. D. Hull, *Jour. Amer. Chem. Soc.*, Vol. 41, pp. 1168-1175, August, 1919.

[3]Chemical Analysis by X-Ray Diffraction, by J. D. Hanawalt, H. W. Rinn, and L. K. Frevel, *Industrial and Engineering Chemistry*, Vol. 10, No. 9, pp. 457-512, September 15, 1938.

[4]Symposium on Radiography and X-Ray Diffraction Methods, American Society of Testing Materials, 1937.

[5]*Applied X-Rays*, by G. L. Clark, 2nd edition, McGraw-Hill Book Company, New York, New York, 1932.

[6]*Study of Crystal Structure and Its Applications*, by W. P. Davey, McGraw-Hill Book Company, New York, New York, 1934.

[7]Materialprufung mit Rontgenstrahlen, by R. Glocker, Julius Springer, Berlin, 1936.

[8]Rontgenographische Untersuchung von Kristallen, by F. Halla and H. Mark, J. S. Barth, Leipsig, 1937.

[9]*Structure of Crystals*, by R. W. G. Wyckoff, Reinhold Publishing Corporation, New York, New York, 1930-34.

[10]Davey, W. P., General Electric Review 25, p. 565, 1922.

[11]Die Verwendung von Rontgenstrahlen in Chemie und Technik, by H. Mark. Leipsig Verlag, J. A. Barth, 1926.

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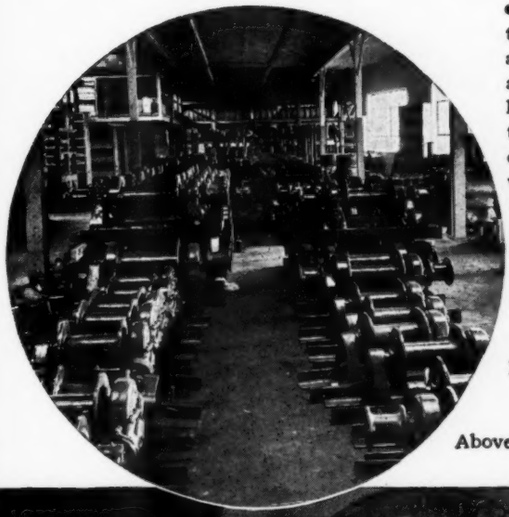

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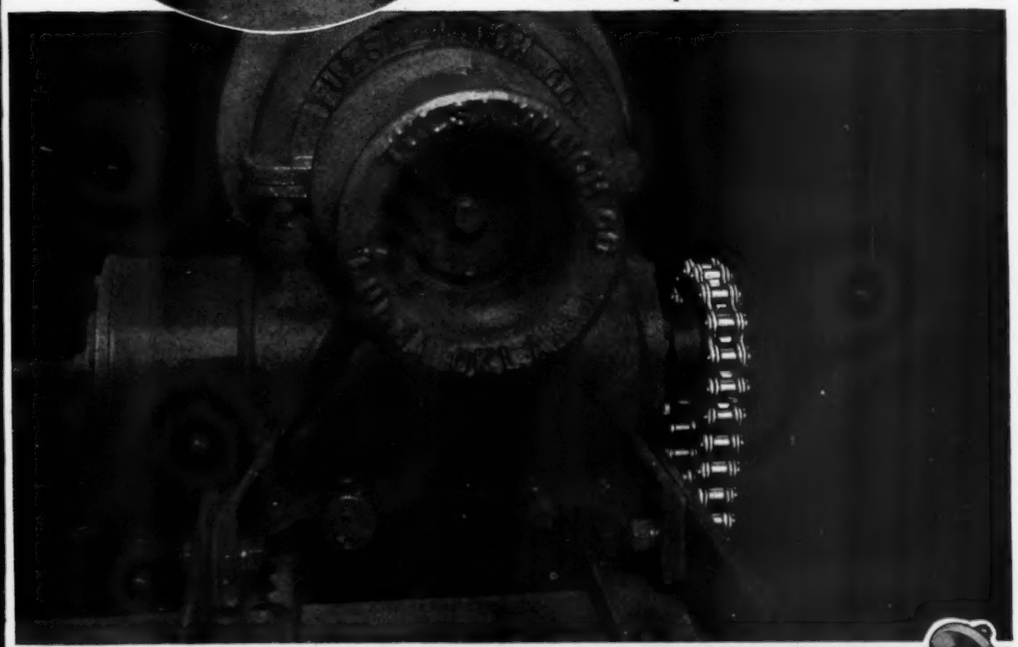

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Improved Acidizing Mixtures Speed Separation of Spent Acid and Oil

Elimination of corrosive acids and salts from crude oil avoids corrosion of equipment in pipe line and refinery

By C. E. CLASON

Halliburton Oil Well Cementing Company

SEVERAL years ago, smaller local refineries in areas of limestone production noted a decided increase in corrosion problems. These problems coincided with the increasing use of acid to increase oil production from wells that supplied these refineries. The situation was generally accepted as a necessary evil but, nevertheless, several different methods were evolved to cleanse the oil in an attempt to remove whatever caused the damage.

During the last two years, investigations have thrown more light on the causes of the corrosion and have enabled an attack upon it at the source.

In the past it has been customary to direct all research in acidizing toward putting more oil in the operator's tanks. The condition of this oil did not always matter if a good potential was obtained. Any necessary subsequent treatment of the oil for acceptance by the pipeline was considered a necessary part of the process.

It has been established that spent acid has remained in solution with oil produced from a well, in varying quantities for more than ten weeks following acidization. It is also known that the salt content of the oil was increased for a long period of time subsequent to treatment. Lately, it has been discovered that some types of crude oil actually seem to react with acid, forming a stable emulsion that never breaks in some cases, and in others, will break in twenty minutes to several hours. Some formations contain enough gypsum to create a real problem when the gypsum is dissolved by the acid and then reprecipitates, causing a plugging of the formation.

Hindrances to obtaining more oil by the use of acid have gradually been overcome by methods that have proved themselves as shown by their wide use in the last one to five years. It is now proposed that another benefit be derived from the use of these methods, that has not been appreciated or realized thus far.

It is known that when acid has been treated with a substance that changes the interfacial tension between the acid and the oil, thus permitting faster penetration and an easier flowing quality through both large and small channels, the spent acid should possess this same characteristic. This being true, it should follow that the removal of this spent acid from the well will be faster, i.e., there will be less tendency to remain in the formation channels. Thus, an acid of this type will shorten the time during which the oil is subjected to contact with the acid. Periodical sampling will show a consistent lowering of the salt content in much less elapsed time and before so much oil has been produced as formerly.

C. E. CLASON

for 20 years was with Dow Chemical Company, Midland, Michigan, as analytical chemist, plant superintendent, and doing inorganic research—In the summer of 1932 he was placed in the Acidizing Department, having charge of the Michigan district—Was transferred to Kansas in January, 1933, as district manager to pioneer the work there—In May, 1935, entered the employ of the Halliburton Oil Well Cementing Company, as superintendent of the Acid Division.

At this point, it might be well to mention one principal evil of high salt content in an oil. The hazard lies in the higher magnesium chloride content produced by action of the muriatic or hydrochloric acid with magnesium carbonate in the formation. This product decomposes under high temperature, forming magnesium oxide and hydrochloric acid. It can readily be seen that a source of corrosion is thus presented that will produce dire results in a refinery.

Unless emulsion of acid and oil are prevented by using a proper destabilizer when acidizing a well, some of the acid is either slowly reactive with the formation or does not react at all and may be produced into the tanks with the oil. Some of the so-called solubility of hydrochloric acid in oil is no doubt due to the presence of a reaction product that is only broken down by heat later on. If the product is unstable, it may break down after being pumped into the formation. Enlarged pores in the channels may be created, which could also account for the long delay before the spent acid is removed completely. Spent acid trapped in these pockets could be bypassed and only picked up gradually by the oil.

The effect of emulsion preventers is also evidenced in the quicker separation of the spent acid and oil in the tanks. Pipe-line oil has been obtained in many instances in from 30 minutes to an hour, when formerly treatment of the oil was necessary to effect a separation. A faster separation means a cleaner oil for the refinery.

More attention is also being given to the type of oil used to force the acid into the formation. Oil used for this purpose is usually designated in the field as flushing oil and it is no longer good practice to pick up contaminated oil from a pit to accomplish this final act in acidizing.

It has long been considered by many operators that acid was acid and that the removal of limestone was the only objective of acidizing. In some cases this has been true when all that was desired was more oil production from a well. The time is fast approaching, however, when the overall picture will be viewed, and one branch of the industry will no longer have costs raised and be penalized by another.

See What Jarecki MANUFACTURES

—at our Oil Show exhibit, Booths 87 and 88, Texas Building

JARECKI is the only oil field supply company that manufactures valves and fittings

You are acquainted with JARECKI as one of the largest distributors,—through our oil field stores,—of wire rope, oil country tubular goods and all kinds of oil field equipment. But do you know what JARECKI manufactures?

JARECKI started in as a manufacturer of valves and fittings 7 years before the birth of the Oil Industry. Today JARECKI is one of the world's largest makers of cast iron, malleable iron, semi-steel and brass fittings, valves and special fittings. JARECKI also manufactures a number of patented oil field specialties. Our big factory at Erie manufactures and carries in stock approximately 7,000 different valves, fittings and specialties.

Our exhibit at the Oil Exposition will be designed to give a comprehensive idea of our manufactured line. Won't you pay us a visit during the world's biggest oil show?

Main Plant of the Jarecki Manufacturing Company, Erie, Pa.

Jarecki

MANUFACTURING COMPANY

"Since 1852"

General Offices: St. Louis, Mo. Home Office and Factory: Erie, Pa., U. S. A.
District Offices: Pittsburgh, Pa.; Tulsa and Bartlesville, Okla.; Dallas and Houston, Texas; Mt. Pleasant, Mich.; Centralia, Ill.
Branch Stores at All Important Places in the Oil Country.

MACHINERY and EQUIPMENT

High Temperature Swing Joint

THE NEW Chiksan High Temperature Swing Joint is designed for operation at working pressures to 500 lb. at temperatures to 700°F. Care

has been taken to provide for unobstructed flow through all bends. Increased diameters are provided at the elbows to assure maximum flow with minimum pressure drop.

There are no packing glands or stuffing boxes to repack; no nuts or bolts to keep tight. This joint does not depend for its rigidity on bolted flanges, threaded parts, locking rings or keys of any type. All pressure or load is transmitted through double rows of hardened steel balls in flame-hardened races. The pressure or load required to force the members of this joint apart would have to be equal to the shearing strength of the metal. As the shearing strength of the metal is greatly in excess of the rated capacity of the joint, a wide margin of safety is provided.

To provide a smooth, long-wearing surface, the packing chamber is machined to close tolerances and then chromium-plated and polished. The packing set is a specially designed combination of asbestos and brass rings and is held in place by the tension of a special alloy wire spring that retains its resiliency under high temperatures, and is also efficient at lower temperatures. The packing is not affected by chemicals that are injurious to rubber or synthetic compounds, the manufacturer asserts.

The new Chiksan High Temperature Swing Joint is made in 6 different styles for full 360° rotation in one, two, and three planes. These styles are recommended for applications handling steam or chemicals where temperatures do not exceed 700°F. or a working pressure of 500 lb.

Chiksan High Temperature Swing Joints are manufactured and distributed by the Chiksan Tool Company, Brea, California. The style illustrated is No. 60, for applications where rotation in two planes is required.

Unibolt Steel Couplings and Fittings

THE accompanying photograph of a 2-wing, 6000-lb. test Christmas tree illustrates the use of standard Unibolt steel couplings and fittings.

The top connection on the cross is provided with a blanking plug that is tapped for a pressure gauge. This blanking plug, interchangeable with standard Unibolt steel couplings, eliminates the use of a bull plug on top of the tree and provides easy and quick access to the well for running bottom-hole pressure bombs or paraffin scrapers. By attaching a plain hub and holding member of a Unibolt steel coupling to the bottom of the lubricator, it can be quickly attached to any Unibolt connection of the same type or size.

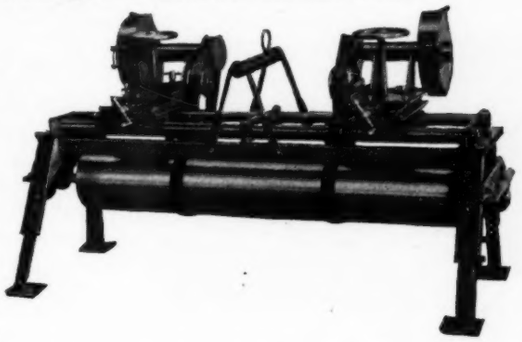
The adjustable choke shown on one wing of the tree may be converted into a positive type choke by replacing the bonnet assembly and stem seat with a blanking plug and positive bean, respectively. The bonnet assembly itself may then be used to convert any Unibolt positive-type choke assembly into an adjustable type by reversing the above procedure, as the bonnet assembly is freely interchangeable on all Unibolt choke bodies of 2-in., 2½-in., and 3-in. sizes.

The Unibolt cross shown on the opposite wing of the tree has a blanking plug similar to those on the top of the tree and on the tubinghead outlet, and is provided with a bleeder-type plug for releasing trapped pressure. A cage nipple and positive bean may be inserted in the threads opposite the blanking plug, which provides a quick, effective means of changing positive chokes, it is stated.

Instead of flanges, the valves are provided with Unibolt couplings that have been welded on and tested to full rated test pressure. The safety factors of the Unibolt couplings compare favorably to the safety factors of A.P.I. flanges and they effect considerable saving in weight and assembly time, the manufacturer asserts. All parts of the Unibolt couplings being interchangeable, the tree may be converted into a one-wing tree by simply removing one wing and installing a blanking plug.

The manufacturer, Thornhill-Craver Company, Inc., Houston, Texas, has compiled detailed data concerning Unibolt couplings, a copy of which will be sent to interested operators on request.

Rotary Drum Flanges Serviced on the Job

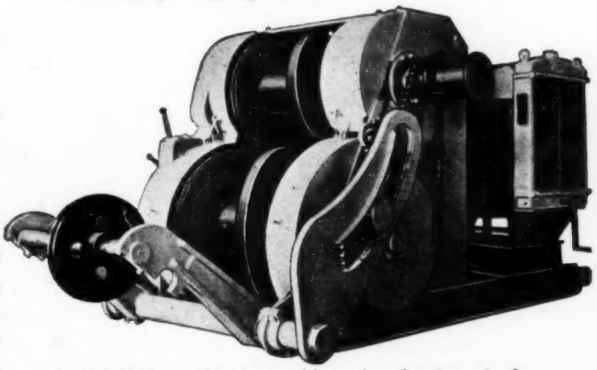


ELIMINATING the necessity of removing rotary drum flanges from the drawworks or the drum, a portable flange grinder has been developed by Patterson-Ballagh engineers. It is a simple, rugged unit that will hold a close adjustment under heavy oil-field duty, and can be operated by the regular drilling crew, the manufacturer states. By its use flanges can be ground when the first grooving takes place. Thus a large saving is effected in brake lining, it is stated. The machine is a portable double grinding unit having two carriages operated similar to a lathe. Independently operated carriages travel lengthwise on large common cross shafts or slide rails. Each carriage mounts a 14-in. grinding wheel, individually housed, equipped with safety glass windows and lighting fixtures. The countershaft, situated in the center of the unit running parallel to the drumshaft, drives both grinding wheels at the same speed. Each grinding wheel can be moved to the right or left, advanced or returned, independent of the other wheel. Grinding is parallel to the drumshaft at all times. Alignment is accurately maintained.

The unit is driven by any portable gas engine of 10 hp. or more, or by an electric motor. The shipping weight of the complete machine is 1400 lb. To line-up and start grinding is a matter of only a few minutes. A coarse wheel makes the rough cuts and takes most of the wear. A finishing cut with a finer wheel surfaces the flange like a mirror. The countershaft is equipped with sealed ball-bearings, and pillow blocks are set in rubber to reduce vibration.

Further details may be obtained from Patterson-Ballagh Corporation, 1900 East 65th Street, Los Angeles, California.

Unit Rig Equipment



Model U-16 combination cable-tool and rotary rig for medium depth rotary and deep cable-tool drilling

SINCE the introduction by the Unit Rig and Equipment Company, Tulsa, Oklahoma, of its rotary drilling unit, the Model U-10, several other designs have been placed on the market. The U-10 was followed by the U-12 Reverse Clutch and U-14 Dual Engine Hook-Up, after which came the Model U-16 Combination Rig. This last-named unit may be supplied strictly as a double drum rotary drawworks with spudding attachment obtainable later if desired. The general design and construction permits the use of larger engines and increased drum sizes. Some of the outstanding field applications include rotary or cable-tool drilling, drilling-in, drilling deeper, pulling or ripping casing, and general well-servicing for all depths.

Another of the company's items is the Model U-17 service hoist. This is essentially a rod and tubing hoist, but can readily be fitted with a rotary attachment for drilling wells to as much as 3000 ft. when adequately powered. A spudder crank can be substituted for the rotary sprocket for fishing, cable-tool drilling, and tailing-in. The U-17, when combined with the Model U-19 auxiliary spudder, will handle all types of work usually done by double drum spudder units, the manufacturer asserts. The Model U-19 auxiliary spudder unit was developed for the use of lease operators and contractors for use on isolated clean-out jobs, for fishing, for drilling deeper, and for tailing-in after rotaries. It is a compactly designed and well-constructed unit that can be easily transported and although it will not entirely supplant the large, conventional, double drum spudder unit, it is designed to give operators a practical combination unit for servicing and drilling to 4000 ft.

Model U-20 telescoping mast is of the two-legged, steel, telescoping type. The crown has three large alloy-steel sheaves running on ball bearings. The mast, made of heavy seamless steel pipe, will extend to 57 ft. and collapse to 35 ft. overall length.

Larkin Neoseal Packers Made With Neoprene Pack-offs

THE Larkin Packer Company, St. Louis, Missouri, has announced an important improvement to its packer line—the Larkin Neoseal Packer—a hook-wall pumping packer that incorporates several new features both in design and material.

The packing element in this new style packer is now made of neoprene, an oil-resistant synthetic rubber, which, according to company officials, offers many operating advantages.

In 1905 Larkin packers were first manufactured to meet the need for equipment that would permit controlled release of gas from oil sands where it is necessary to obtain economical production from wells having considerable fluid but little pressure. The product has been improved through the years and with the addition of many other styles of packers to the line, has kept pace with the needs of industry.

Experiments that led to the use of molded neoprene as the packing element in Larkin packers were carried on in the company's own laboratories. It is asserted that neoprene allows a packer to be reset over and over despite continued contact with oil, water, gas, heat, and pressure and that, under heavy loads, it resists deformation and shows no tendency to vulcanize to the casing. When pulling or raising the packer, a steel ring is mechanically stretched away from its packed position to eliminate the swabbing effect, it is stated. Other improvements include many refinements of design, most important of which is a completely new spring, rein, and slip assembly.

In addition to the regular style, this packer can be supplied with a control head assembly that provides a bypass when running in a flowing or gassing well, or when pulling the packer from a hole full of fluid. With a minor change, this control head assembly is adaptable to gas-lift installations.

Franks Portable Spudder

A SPUDDER for deep Gulf Coast wells, capable of drilling to 10,000 ft., has been designed for mounting upon a truck, making it entirely portable, moving under its own power and taking drive from the truck motor. The accompanying illustration shows a unit designed by the Franks Manufacturing Corporation, Tulsa, Oklahoma.

The unit is on an A-8 International truck. Friction drives are employed throughout, with final friction drive on drilling drum and sand reel. The drilling drum has 52-in. flanges and 10-in. brakes and a spooling capacity of 9000 ft. of ⅞-in. line. The sand reel has 42-in. flanges, 8-in. brakes and will spool 8000 ft. of ¾-in. line. It has an independently driven cathead. The power is from the PA 100 International truck motor through a power take-off. The unit stays within the state laws limiting the width of any vehicle used on the highways to under 8 ft.

SEALING PRESSURES SINCE 1888

NOW non-scuff, double-quick seating
COOK'S PISTON RINGS
. . . they're TINIZED*

*COOK'S EXCLUSIVE SURFACE TREATMENT

It's the coating of anti-friction metal that . .
- Reduces Friction
- Promotes Double-quick Seating
- Prevents Cylinder-Scuffing
- Increases Cylinder Life
- Cuts Break-in Costs
- Safeguards Existing Cylinder Glaze When Replacing Rings

. . . which further reduces friction and prolongs ring and cylinder life . . .

A new development since the last Oil Show . . . one you will want to see and know all about because of the improved operation and economy it achieves . . . a development that gives COOK'S GRAPHITIC IRON Rings the added important advantage of *pre-conditioned wearing surfaces* . . . a feature that ends the danger of damaged cylinders on initial operation after installing new rings—that speeds up operation by promoting quicker "mating" between cylinder and ring surfaces—that cuts maintenance costs by increasing cylinder and ring life. See these new TINIZED rings at the Tulsa Show—also the full line of COOK'S Rings. We cordially invite you to visit our booth.

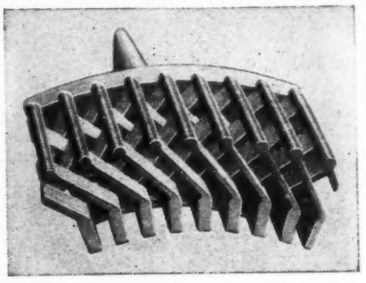
See Our Exhibit INTERNATIONAL PETROLEUM EXPOSITION TULSA MAY 18-25

BOOTHS 51 - 52 Texas Building

C. LEE COOK MANUFACTURING CO.
INCORPORATED
New York Cleveland Los Angeles Baltimore LOUISVILLE, KY. Chicago Tulsa New Orleans San Francisco

G-E "Valv-Amp" Rotor

SAID to offer the advantage of longer motor life with less maintenance, a new type rotor construction has been announced by General Electric Company, Schenectady, New York, which makes possible the use of cast-aluminum rotors in the larger sizes of double-squirrel-cage motors for high-starting-torque, low-starting-current service. Called the "Valve-amp" rotor, it makes use of a unique shape of rotor slot and a special method of assemblying rotor punchings to control the flow of starting current. As a result, without the use of a switch or other moving parts, current is permitted to flow in the outer squirrel-cage when the motor is started, thus producing high-starting torque. Then, when the motor comes



up to speed, current is allowed to flow through the entire rotor "winding", resulting in excellent running characteristics.

Of the two conventional methods of double-squirrel-cage-rotor construction, i.e., casting the conductor bars and short-circuiting rings integral or joining them by brazing, the former method is by far the more satisfactory because it is a simpler operation, with smaller chance for human error, and results in a more compact, uniform product, General Electric engineers state. Until the Valv-amp development, however, it was not practicable to cast double-squirrel-cage rotors in the larger sizes.

The Valv-amp development allows the construction of larger cast-rotor

motors, which inherently combine the advantages of the double-squirrel-cage motor, such as high-starting torque, low-starting current, and excellent running characteristics, with advantages of the conventional cast-rotor motor — simplicity of construction, long motor life, little maintenance, and permanence of electrical characteristics, it is asserted.

Ozalid Model "A"

THE OZALID Model "A" automatic high-speed whiteprint machine employs a new quartz envelope high-pressure mercury vapor lamp, which provides an extremely fast

printing speed, ranging to 20 linear ft. per minute, and assures uniform distribution over the entire printing surface. This lamp, guaranteed for 1000 hours, is new to the reproduction industry, and has been designed and manufactured especially for this machine.

The Ozalid Model "A" automatic high-speed whiteprint machine is available in two sizes for production of prints to and including 42- and 54-in. widths. An ingenious device automatically separates the print from the original after-exposure. The original is returned to the operator in front of the machine, and the exposed print is automatically conveyed to the developing unit, where, after dry development, it is discharged at the rear of the machine ready for immediate use.

A variable transformer in the primary circuit permits a variation of intensity of the high-pressure mercury vapor lamp from full brilliancy to 60 percent of light without loss of energy. This dimming arrangement is extremely important, for it allows the operator to select the desired intensity, and permits continuous and uniform production of prints, despite variations in tracings.

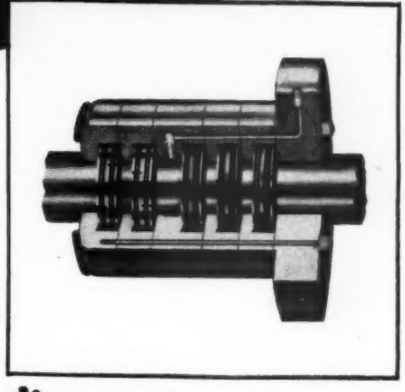
The high-pressure mercury vapor lamp is cooled by an alternating air blast, which passes through the space between the revolving contact cylinder and the fixed cylinder surrounding the quartz envelope high-pressure mercury vapor lamp. By alternating the cooling air stream, high temperature between the left and right sides of the contact cylinders is avoided. A small, metered quantity of cooling air is also allowed to enter and pass through the inner cylinder and over the quartz tube; thus, the temperature of this lamp is maintained within a relatively small range. This temperature control is absolutely essential for this type of light.

In this machine, positive printing and dry developing are synchronized, and both of these operations are brought together in a streamlined, compact, easy-to-operate machine, which is completely revolutionary in design, construction, and performance, according to the manufacturer.

The equipment is manufactured by the Ozalid Corporation, Johnson City, New York.

SEALING PRESSURES SINCE 1888

NOW non-scuff, double-quick seating
COOK'S PACKING RINGS
. . . they're TINIZED*



. . . which further reduces friction and prolongs rod and packing life . . .

* Patent applied for

ANOTHER new COOK development since the last Oil Show . . . COOK'S Metallic Rod Packings for extreme service conditions now fitted with COOK'S GRAPHITIC IRON packing rings having *pre-conditioned wearing surfaces* . . . a feature that reduces friction—protects the rod from wear during the break-in operating period—promotes quicker "mating" of ring and rod surfaces—prolongs life of rod and packing—cuts maintenance expense. Make it a point to see these new TINIZED packing rings at the Tulsa Show—also the complete line, made of COOK'S GRAPHITIC IRON, COOKMET, Hard Babbitt and Laminated Bakelite. We cordially invite you to visit our booth.

INTERNATIONAL PETROLEUM EXPOSITION TULSA MAY 18-25

BOOTHS 51 - 52 Texas Building

C. LEE COOK MANUFACTURING CO.
INCORPORATED
New York Cleveland Los Angeles Baltimore LOUISVILLE, KY. Chicago Tulsa New Orleans San Francisco

Line Saver Picks Up Wickers From Wire Lines

ALTHOUGH developed to save wire lines and prevent such line troubles as bowing and whipping, the Grizzly "No-Wip" line saver definitely has proved its worth as a safety device, according to Walter G. L. Smith, president and general manager of E. M. Smith Company of Los Angeles, California, manufacturer of the appliance.

In support of this statement Smith offers herewith evidence in the form of an unretouched photograph of a rubber roller taken from a line saver that had been in service for several months. Even in this illustration, hundreds of wickers of all sizes imbedded in the rubber body are clearly discernable to the naked eye. Each of these wickers is a potential hazard to workmen in the rig if they are not picked up by the rubber rollers, Smith contends, and might be the cause of impaired or even totally destroyed vision of one or more of the workmen on the rig.

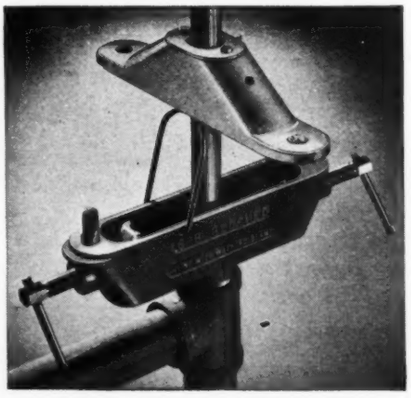
As wire lines wear, thousands of these wickers are scraped from the strands through contact with various derrick equipment. When the Grizzly line saver is used, however, the wire lines are constantly in contact with the rubber rollers, and the wickers are picked up by these rollers.

It is claimed by the manufacturer that the Grizzly line saver prevents excessive wear of wire lines and saves miles of these valuable lines every

year; prevents whipping without straightening or injuring the line, and simplifies spooling and prevents piling up at any area on the drum. When pulling up an empty block and elevator, the usual bow and whip due to momentum is eliminated, permitting the line to spool perfectly without crawling or overlapping, it is stated. It is a carefully engineered device that can be suspended at any point in the derrick, hangs freely at any height over the drum, and functions properly at any angle, the maker asserts. It is not to be mistaken as a rigid line guide. Further information may be obtained from the manufacturer by requesting Bulletin No. 10-OF.

G-B Red-Hed Stuffing Box

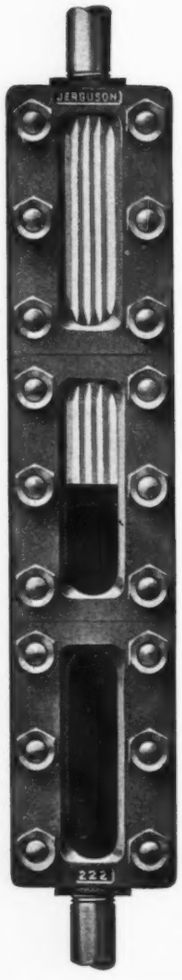
IN THE NEW Red-Hed stuffing box, developed by Gustin-Bacon Manufacturing Company, Kansas City, Missouri, the packing element consists



of two interlocking halves fitting around the polished rod.

JERGUSON

REFLEX GAGES



are preferred by the Oil Industry because of their reputation for maximum efficiency at all temperatures and pressures.

Easy to read because the . . . .

EMPTY SPACE SHOWS
WHITE

LIQUID LEVEL APPEARS
BLACK

Ideal for tanks, towers, stills, etc., carrying gasoline, kerosene, oil, no matter what the color of the liquid.

Furnished with or without valves for every type of service.

When you need to show the color and density of liquids, use Jerguson Transparent (thru vision) Gages.

There's a JERGUSON GAGE for your plant

JERGUSON GAGES are best by every real test

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As the polished faces of the packing elements become worn, the two segments may be moved closer together by the vise-handled take-up screws. Thus, the tendency of a polished rod to create an oval hole due to its lateral movement in the plane of the walking beam is anticipated, even utilized to advantage, in the interlocking feature of the stuffing box. The packing elements are made of Meshtite, a patented rubber material.

The accompanying photograph shows the cover of the stuffing box lifted and held in a raised position by a wire bail or "third hand" so that both hands may be free to make the infrequent rubber replacements that are required.

Under the top plate of the cover is a wiping ring that may be replaced by removing the two cap screws holding the top plate in place. An ample supply of oil is contained in the body of the cover to provide lubrication until the fluid reaches the tubinghead.

For wells having an excessive lateral movement of the polished rod, the Red-Hed stuffing box is available with a Wobbler—a sealing ring that affords flexibility and provides for deflection in all directions.

A Twinset adapter is also available so that two Red-Hed stuffing boxes may be installed, if desired. The lower one is used when the upper, or working, box must be re-packed. At other times, the lower rubbers would be retracted.

Chrome Face Steel Tape

"CHROME FACE" is the name of the line of steel measuring tapes that has just been placed on the market by The Lufkin Rule Company, Saginaw, Michigan. These tapes have markings that are durable as well as easy to read.

The tapes are accurate, the makers state, are chrome plated, and have jet black markings and satin chrome-white surface, free of glare. Hence, the permanent markings stand out in sharp contrast, showing up well even in poor light. Furthermore, being built-up by chrome plating these tapes are extra strong and resist rust, it is asserted. The surface is smooth, hard, and easy to clean, and the tape, being of metal throughout, will not crack, chip, or peel. New cases and frames of improved design and appearance have been built for this new line.

As a tank gauging tape the chrome-face line will appeal most strongly to the oil industry for two principal reasons: On its dull chrome-white surface the oil line is easy to find and the measurement is easy to read, even in poor light. A full line of chrome-face gauging tapes is now offered, including the popular "Atlas," also the others with plumb bobs of various patterns.

"Anchor" is the brand of the chrome-face tape in genuine leather case. Such tapes are offered graduated either in feet, inches and 8ths or feet, 10ths and 100ths, and with lines in both ⅜ and ½ in. width. The ½ in. is especially suitable for general measuring in the oil industry because its greater width gives it added durability and it accommodates larger figures.

Reilly

PIPE LINE PROTECTION PAYS BIG DIVIDENDS!

★Oil and gas pipe lines, protected with Reilly Primer and Pipe Enamel are singularly free from the costly annoyances of service interruptions. Reilly coatings are unaffected by temperature variation and will not sag or flow at elevated temperatures nor chip or crack at low temperatures. They are highly resistant to abrasion. With such qualities, Reilly Coatings give positive and dependable protection against every corrosive agency. Booklet mailed on request. No obligation.

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FIFTEEN · PLANTS · TO · SERVE · YOU

Fisher Low-Pressure Service Regulator

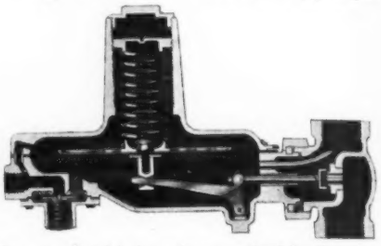
AN IMPROVED low-pressure gas service regulator is announced by the Fisher Governor Company, Marshalltown, Iowa. Outstanding feature of this new unit is the safety relief valve built integral with the regulator. This results in a considerable reduction in overall dimensions and simplifies piping, particularly for indoor installations, the manufacturer states.

The built-in relief valve of this Type 733-A House Service Regulator is diaphragm-actuated, spring-controlled, and normally is factory set and sealed to relieve at 1 lb. The upper diaphragm chamber is arranged to vent through the relief outlet.

All working parts are easily accessible without breaking pipe joints. Valve bodies are interchangeable. Interior construction provides automatic loading, assisting the regulator in maintaining a constant reduced pressure even though flow demand may be high.

Diaphragms in Type 733-A are highly sensitive and extremely tough; they are made of a special non-porous composition impervious to gases, it is stated.

Type 733-A is available in ¾ in., 1

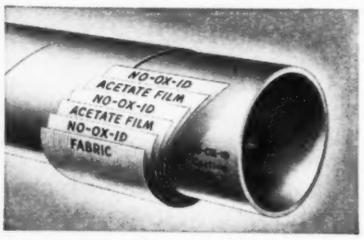


in., and 1¼ in. sizes, suitable for initial pressure to 150 lb. and recommended for reduced pressure ranges of 2 in. to 10 in. of water and 7 in. to 16 in. of water.

No-Ox-Idized Pipe Wrapper

FOR protecting pipe and pipe coatings where moisture conditions are unusually severe, a new wrapper, known as the No-ox-idized Dielectric Wrapper, has been developed in the research laboratories of the Dearborn Chemical Company.

This wrapper employs an open-mesh fabric and two sheets of heavy acetate membrane, each coated on both sides with No-ox-id. All are laminated together into a single wrapper. The two



layers of acetate membrane give this wrapper a high dielectric strength and an unusually high resistance to the penetration of moisture, the manufacturer asserts. The acetate laminations are insoluble in oil. These properties make the No-ox-idized Dielectric Wrapper especially valuable for protecting underground pipe in those localities where the ground is intermittently wet and dry or oil soaked.

The flexibility of this new wrapper makes it suitable for hand application to welded joints. The consistency of the No-ox-id used, together with the flexibility of the open-mesh fabric, provides a seam that is self-sealing.

When used with other kinds of protective coatings, this wrapper prevents loss of volatile matter or oxidation of coating and gives protection against mechanical injury and water penetration, it is stated. The fabric on the outside of the wrapper provides a good bonding surface when a final service coat is to be applied.

For full information, write Dearborn Chemical Company, 310 South Michigan Avenue, Chicago, Illinois.

POWER
21
Continental
Red Seal
SIZES
Continental
CONTINENTAL MOTORS
AMERICA'S STANDARD
Whether for spudding, drilling, pumping (individually or from central power plant) generator service for power or lighting, the operator must give careful consideration to power units that are built to "take punishment." Continental Red Seal Engines can "take it," because they're built for it.
1. Quick, push-button starting.
2. Individual porting (an exclusive patented Continental feature) which means smooth, balanced power.
3. Full length of cylinders surrounded by water for efficient cooling with jackets designed to eliminate hot spots.
4. Precision, interchangeable steel backed bearings.
5. Dust and dirt proof crankcase.
6. Cast iron base with extra large oil capacity available for all models.
Distributors with Sales and Service Facilities
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316 Thompson Building, Tulsa, Oklahoma
ORIENTAL TRANSMISSION & PACKING CO.
2615 Commerce Street, Dallas, Texas

Gasoline and Oil Meter

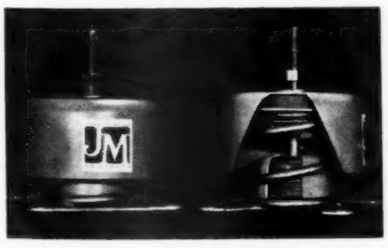
EXTREMELY high degree of accuracy and low pressure loss are the outstanding characteristics of the newest addition to the Smith Meter Company's line of gasoline and oil meters, officers of the company state. Known as the S-12 Meter, this unit has 2-in. flanged connections in line for convenient bolting into the pipe line, and is built for 125-lb. pressure. The meter has a sustained capacity rating of 120 U. S. gal. per min. and a hairline accuracy that can be regulated to micrometer dimensions by the new, built-in calibrator. The calibrator adjusting dial is situated outside the meter, under a small cap that can be sealed, thus preventing unauthorized persons from changing the adjustment.

Pressure loss through the meter is less than the loss through two pipe elbows of the same size as the meter connections. This low pressure drop—a characteristic of all Smith petroleum meters—is brought to the highest development in the S-12 meter by the use of streamlined flow passages, together with liberal use of high-grade stainless ball bearings, it is asserted.

Used for bulk plant loading racks, pipe lines, refinery, and similar services, the S-12 meter can be supplied with a horizontal reset counter, incorporating a totalizer; a horizontal non-reset counter (totalizer only); a 6-in. diameter vertical dial, with totalizer; a 10-in. diameter vertical dial, with totalizer, or a ticket printer.

Machine-Vibration Isolator

A NEW, easily installed vibration isolator, designed to control machine vibration economically and reduce the resulting noise, was recently announced by Johns-Manville, New York City. The device, known as the J-M Controlled Spring Isolator, was developed for use on the bases of motors, generators, pumps, ventilating fans, and similar equipment where vibration and excessive motion create noise and tend to wear out machine parts and damage connections as well as crack the supporting walls and floors.



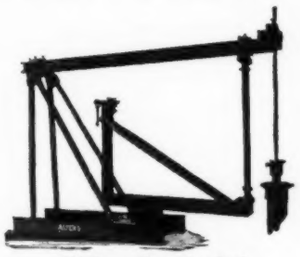
The working parts of the unit consist of a coil spring and a rubber load pad, which support the equipment and isolate vibration, and an adjustable rubber snubber inside the base, which controls excessive motion. Through the combination of these parts, the manufacturer states, the isolator provides both the high compliance necessary for good isolation and the control needed to limit motion in the equipment.

The isolator was built to take care of horizontal and torsional as well as vertical vibration, and tests by the J-M Research Laboratories, where the unit was developed, indicate it to be particularly efficient for the low-frequency vibrations resulting from slow speeds and from many operations involving reciprocal action. The load pad is designed to overcome any high frequency vibrations.

The isolator is made in two sizes: Light Duty for loads from 60 to 190 lb. per isolator; and Heavy Duty, for loads from 250 to 720 lb. per isolator. Heavy machines may be isolated by clusters of the units. The loaded overall dimensions of the isolator are 6 in. by 6 in. by approximately 3¾ in. high. It is enclosed in a metal jacket that protects the rubber parts from oil and sunlight.

Alten's *A-50-TC Pumping Unit*

QUALITY PRODUCTS



Oklahoma Pumping Jack

Underpull Pumping Jacks
Oklahoma Pumping Jacks
Pumping Units
Pull Rod Swings
Throw Off Irons
Surface Equipment
Flexible Stuffing Boxes
Paraffin Scrapers
Essex Lock Cocks
IBBW Stop Cocks
Casing and Tubing Heads

Also Many Other Items. Write for Our Catalogue No. 20

Paraffin Scraper

A-50C Underpull Jack

See Our Exhibit
INTERNATIONAL PETROLEUM EXPOSITION
TULSA
MAY. 18-25

Outside Space in Block 7 on West Virginia Avenue and Beville Lane

Flexible Stuffing Box

ALTEN'S FOUNDRY & MACHINE WORKS

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Browning Hotel
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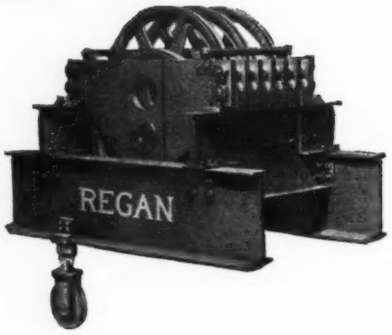
CHAS. L. SPILMAN
1709 S. 12th St.
Mt. Vernon, Ill.

HENRY A. WINLAND
712 N. Broadway
Salem, Ill.

600-Ton Crown Block

TO handle the heaviest derrick loads in deep drilling, Regan engineers developed a 600-ton capacity crown block, Type EH. Additional improvements have been added to amplify the structural strength. The cross beams are now welded to heavy plates, forming the most rigid assembly. This crown block is constructed to provide a simple, continuous, over-and-over reeving, using large diameter sheaves, the manufacturer states. It is equipped with six or seven 48-in. diameter sheaves, grooved for 1-in., 1⅛-in., or 1¼-in. diameter wire line. There are no castings with the exception of the sheave, and the spacers between the sheave beams. The other parts are of rolled steel plates and I-beam sections. Additional details can be obtained from Regan Forge and Engineering Company, P. O. Box 150, San Pedro, California.

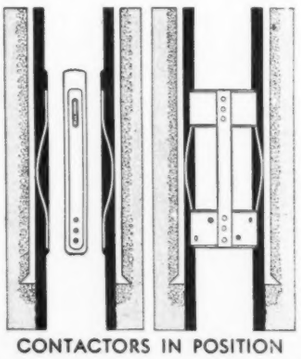


Security Drillable Liner-to-Casing Contactors

SECURITY Casing Contactors, manufactured by Security Engineering Company, Whittier, California, are used in connection with installations of Securaloy drillable oil-well liners to shunt electric currents flowing between liner and casing, and can be used either for cemented or uncemented liners. In the case of cemented liners, the contactors also centralize the liner to permit even distribution of cement.

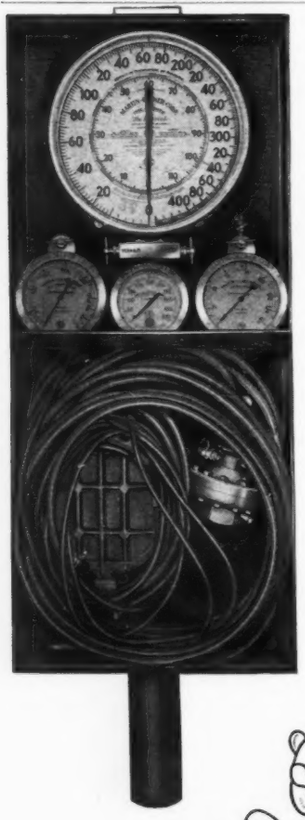
DESIGN A-1465 DESIGN B-1465

Design A-1465 casing contactor mounts directly on the liner and is used when the clearance between liner and casing is slight. Design B-1465 casing contactor is a standard slipover type, available to fit any size liner and is used when the clearance between liner and casing is sufficient to pass the contactor collars.



CONTACTORS IN POSITION

Security liner-to-casing contactors are designed for removal with a drilling bit so that their assembly on a Securaloy liner does not impair the drillability of the installation, the manufacturer states.



See the "SEALTITE" at the Oil Show

Pictures are mighty handy — but, Mister, they just can't do justice to this baby. You've actually got to SEE the "Sealtite" to get the full importance of its new construction features!

And if you haven't had the chance to look the "Sealtite" over, drop in to Martin-Decker's booth at the Oil Show. You can take your time, look as long as you want, and we'll be glad to give you all the dope. Remember — Martin-Decker's exhibit in the Reed Roller Bit Building, Block 4, Drake Drive — Tulsa, May 18th to 25th. Be sure to stop in!

P. S. It'll be in full operation on the Continental rig at the Oil Show, too!

See Our Exhibit
INTERNATIONAL PETROLEUM EXPOSITION
TULSA
MAY. 18-25

If you're interested in time-drilling-logging records, see the Rate of Penetration Recorder at the Martin-Decker exhibit also. Feel free to talk it over with us and get all the facts.

HOME OF THE WEIGHT INDICATOR

MARTIN DECKER CORP.

LONG BEACH, CALIFORNIA

SAN JOAQUIN VALLEY: A. F. McQUISTON, BAKERSFIELD, CALIFORNIA
MID-CONTINENT DISTRIBUTOR: REED ROLLER BIT COMPANY, HOUSTON, TEXAS

Diesel Power Unit

A NEW 6-cylinder Diesel power unit that develops 100 hp. at 1400 r.p.m., has been announced by the International Harvester Company, Chicago, Illinois.

As in other International Diesels, this new Model UD-18 engine is provided with a distinctive method of starting by which it starts on gasoline and, after a minute or less of operation,

shifts to full-Diesel operation.

The new International UD-18 Diesel power unit is of rugged, compact construction and is provided with heavy, large-diameter flywheel. It has ample weight (approximately 3875 lb. less fuel, oil, and water) and reserve strength for heavy-duty service, the manufacturer asserts. Cylinders are individually replaceable and are specially heat treated. Cylinder bore and stroke are respectively 4¾ and 6½ in. Piston displacement is 691 cu. in., regular full-load governed speed 1400 r.p.m., and maximum torque 430 lb-ft. at 800 r.p.m.

Overall length of the new UD-18 Diesel power unit is 95⅞ in.; width, 35⅞ in., and height, 61-7/16 in.

Roller Kelly Drive Bushing

A NEW roller kelly drive bushing for hexagonal kellys called the Type 2RH has been announced by the Baash-Ross Tool Company, Los Angeles, Cali-

fornia. This new bushing, designed for use both in regular drilling and when drilling through packers under pressure, has been constructed with fundamental changes in kelly bushing design to allow more sensitive feeding action, more accurate weight indications, and to prevent binding, tearing, or galling the kelly, the manufacturer asserts.

The new equipment contains six sets of rollers, each set consisting of two hardened rollers of extra large diameter, which alone contact the driving faces of the kelly and are large enough to absorb any torque loads now encountered without corrugating the kelly.

Because a hexagonal kelly is more nearly round in section than a square kelly, the six roller assemblies of the Baash-Ross 2RH Roller Kelly Drive Bushing are adjustable so that all of the 12 extra large rollers are kept in close contact with the kelly faces to prevent rounding the kelly corners. The recesses for the roller assemblies in the drive bushing body and the backs of the roller assemblies are correspondingly tapered. The roller assemblies seat upon semi-circular flat shims, and adjustment in size of the hexagonal opening to fit the kelly can be made by the addition or removal of shims.

MARMON-HERRINGTON *All-Wheel-Drive* TRUCKS *are helping extend Oil Field Horizons* IN EVERY LAND

• Not only in oil field transportation, in established fields, but in *exploration, seismographic work and test drilling* as well, Marmon-Herrington *All-Wheel-Drive* trucks are going places no other trucks can go—doing things no other trucks can do. There's nothing on wheels to equal the performance of Marmon-Herrington *All-Wheel-Drive* Fords and Heavy Duty Trucks in loose sand, deep mud and snow, or up and down steep grades and hills.

All-Wheel-Drive FORDS *and* HEAVY DUTY MODELS

We convert all standard Ford trucks, passenger cars and commercial cars to *All-Wheel-Drive* in our plant, and build a complete line of "heavy duty" *All-Wheel-Drive Trucks* with gross load capacities up to 70,000 lbs. Gasoline or diesel engines. Four or six wheels driving. Chassis and cab only, or with any special oil field equipment mounted. See our exhibit at Tulsa, or write for new pictorial oil service bulletin just off the press. Cable address MARTON, Indianapolis, Indiana, U. S. A.

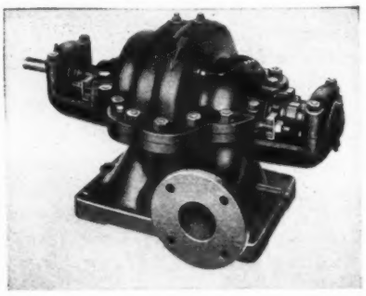
See Our Exhibit at INTERNATIONAL PETROLEUM EXPOSITION TULSA MAY. 18-25

MARMON-HERRINGTON COMPANY, INC.
INDIANAPOLIS, INDIANA, U.S.A.

Two-Stage Pumps By Fairbanks-Morse

TO PROVIDE improved pumping equipment at head conditions above the range of single-stage types, Fairbanks-Morse Company, Chicago, Illinois, has developed a line of two-stage, split-case pumps with capacities to 550 gal. per min. at heads ranging to 600 ft. T.D.H. These units are suited to all classes of general pumping service when the liquid is of low viscosity and free from foreign matter, the manufacturer asserts.

The line incorporates numerous features that contribute to operating efficiency and long service life, it is stated.



One-piece impellers are made of cast-iron, hard bronze, or other alloy depending on requirements. They are mounted "back-to-back" on the shaft to assure proper hydraulic balance. This combination of proper design and correct balance of impeller, together with hand-finished interior surfaces, results in impellers that give superior pump performance, it is stated. Removable wearing rings with streamlined water guiding surfaces are provided on both casing and impeller. The shaft, made of high manganese alloy steel, is journaled in ball bearings of ample size to withstand all thrust and radial loads. Centrifugally-cast bronze shaft sleeves are mounted on the shaft to protect it against abrasive or corrosive action of the liquid.

Horizontally divided bronze glands facilitate removal and adjustment of packing. Stuffing boxes are especially deep to accommodate an adequate supply of packing rings. A bronze water seal ring for clear water in the stuffing box on the low-pressure stage prevents air from entering the pump chamber and reducing efficiency. The compact casing is horizontally divided so that the upper casing may be lifted to expose the entire rotating element.

Fairbanks-Morse two-stage pumps are supplied as basic units, and also as base-mounted units direct-connected to electric motors or steam turbines. Bulletin 5972 describing these pumps more completely will be sent upon request.

Hard-Facing Rod

HAYNES "93" hard-facing rod, a new alloy welding rod for hard-surfacing wearing parts, has been announced by Haynes Stellite Company, unit of Union Carbide and Carbon Corporation. It is recommended by the manufacturer for use where severe abrasion, accompanied by only a moderate amount of impact, is encountered.

The new alloy rod does not possess as high wear resistance as Haystellite cast tungsten carbide products or Haynes Stellite alloys. It is, on the other hand, more wear-resistant but not so tough as Hascrome hard-facing alloy.

Haynes "93" alloy rod is of a ferrous composition and contains chromium, molybdenum, cobalt, and other alloying elements to the extent of more than 40 percent. It has a tensile strength of about 43,000 lb. per sq. in. and a hardness, as-deposited by oxy-acetylene welding, of 62 Rockwell C. When deposits are heat-treated by heating to 1950°F. and then air-cooling, the hardness attains 66 to 67 Rockwell C.

Haynes "93" rod is available from Haynes Stellite Company, Kokomo, Indiana, and from resellers everywhere.

WHEN YOU HAVE TUBING, PACKERS, DRILL PIPE OR CASING TO RUN OR PULL

"Don't kill your Well"

CALL
OTIS

Don't run the risk of injuring your flowing well by loading it with mud or water when tubing, drill stem or casing is to be run or pulled. Instead, call Otis, and let one of their many trained crews run or pull it under pressure, using Otis specialized equipment and methods developed over a period of ten years. ★ Otis crews have handled pipe under pressure in over 4,000 wells, in many of which the surface pressures during the entire running or pulling operations exceeded 2,000 pounds per square inch. Packers have been landed under pressure at depths approaching 9,000 feet. Otis believes this record will stand as a convincing recommendation for their patented methods, equipment and personnel. ★ The cost of Otis service is comparable to, and in many instances even less than, the cost of killing your well. Charges are made on a reasonable daily basis, with a small allowance for moving time. There is no lost production time to be charged against the work when the pipe is handled under pressure. ★ Look in the yellow pages of your telephone directory under "*Oil Field Service*" for nearest Otis representative.

Write or call today.

OTIS PRESSURE CONTROL, INC.
DALLAS, TEXAS

Branches: Houston, Texas; Oklahoma City, Okla.; Hobbs, N. M.
Eastern Representative: Otis Eastern Service, Inc., Wellsville, N. Y.
Western Representative: Western Pressure Control, Inc., Los Angeles, Calif.
Export Office: 74 Trinity Place, New York, New York, U. S. A.

Worthington Balanced Monobloc Pump

A NEW balanced Monobloc centrifugal pump, wherein the motor and pump have been engineered as an integral unit in contrast to merely adapting a motor to a pump, is announced by the Worthington Pump and Machinery Corporation, Harrison, New Jersey.

This new pump is exceptionally compact, yet is provided with ample room

for repacking the stuffing box. A shaft of large diameter maintains concentricity in all rotating parts, thereby increasing packing life.

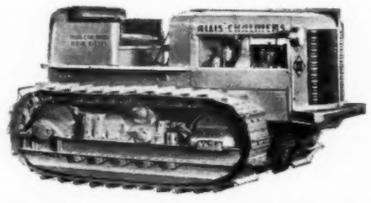
This new Monobloc unit is offered in sizes from 1 in. to 4 in. with capacities to 1000 gal. per. min. against heads to 280 ft. It is available in bronze-fitted, all-iron, and all-bronze construction, horizontal or vertical mountings, with motor of any electrical characteristic.

Complete details, ratings, and dimension tables are contained in the Worthington bulletin W-321-B14.

Allis-Chalmers HD10 Diesel Crawler Tractor

A NEW Diesel crawler tractor—the HD10—has been introduced by the Allis-Chalmers Manufacturing Company as a companion model to the HD14.

Combining the smoothness and power of the General Motors 2-cycle Diesel engine with the cost-saving advantages of Velvetouch bi-metallic steering clutches and brakes, and "Positive-Seal" truck wheels, this tractor is



designed to cut operating costs to a minimum, the manufacturer asserts. The machine is built complete with extra-heavy crankcase, radiator, and truck wheel guards, muffler, hour meter, adjustable radiator shutters, bumper, front pull hook, and electric starting and lighting as standard equipment.

The 4-cylinder engine provides 86 belt hp. and 71.2 drawbar hp. with drawbar pulls to 17,600 lb. The tractor is available in two tread widths, 62 and 74 in., with the narrow model weighing 19,900 lb. and the wide model weighing 20,700 lb.

Constant-mesh gears permit shifting on the go like a truck, with six speeds forward and two reverse. Because the engine can be throttled-down to almost half engine speed without losing drawbar pull, a speed range is provided from 1.58 to 5.67 mi. per hr. This ability to throttle-down in any gear reduces gear shifting and lost time.

The 4-cylinder General Motors, 2-cycle Diesel engine is engineered for high performance at low cost. It is a rugged engine with the advantages of unit injection, four-way cooling, faster acceleration, smoother power, and easy starting, the makers state.

The HD10 is designed to handle two- and four-wheel scrapers to 10-yard capacity, 12-ft. glade graders, bull-dozers, trailbuilders, winches, logging arches, and other allied equipment. A folder describing this new Diesel tractor may be obtained from the Tractor Division, Allis-Chalmers Manufacturing Company, Milwaukee, Wisconsin.

Synthetic Coating Protects Belt Covers

CONVEYOR installations on which conveyor belting is used are often idle for considerable periods. During this idleness belting covers may suffer greater deterioration through the effects of sunlight and air than when the belting is in use. This deterioration also takes place when belts are in storage.

One of the large steel companies, having extensive conveyor installations, had been studying this problem of deterioration, and approached The B. F. Goodrich Company, Akron, Ohio, for coöperation.

As a result of research into the merits of various compositions, Goodrich is now offering a new synthetic coating for belting covers, which on the basis of its tests, will greatly reduce the effects of aging, the makers assert.

Samples of conveyor belting having covers under severe tension were coated with the synthetic composition and exposed for six months to all kinds of weather.

At the end of that period none of the samples of belting on which the new coating had been applied showed any evidence of cover deterioration, it is stated.

The new product has been designated as Goodrich R-60-T protective coating for conveyor belting.

McKissick Safety Traveling Block

THE INCREASING popularity of slim-hole drilling units, and portable and semi-portable rigs, has brought about a demand for a traveling block that is sturdy and strong enough to stand up under the severe strains of modern high-speed rotary drilling and yet is compact enough to allow ample working room in the shorter derricks. The McKissick safety traveling block is designed with a minimum overall length, yet is perfectly balanced and has enough weight to insure straight fall, the manufacturer asserts. Built to run in the smallest coredrilling unit and large enough to work in standard derricks for shallow drilling, the McKissick safety traveling block can be supplied in a size for any unit. These blocks can be supplied with sheaves 10, 12, 14, 17, 18, 20, 24, and 26 in. in diameter and with any number of sheaves. All are built with the McKissick non-detachable safety guards.

Illustrated folders will be sent on request. Address the McKissick Products Corporation, Tulsa, Oklahoma.

Star Drilling Machine

THE No. 82 Speed Star drilling machine manufactured by The Star Drilling Machine Company, Akron, Ohio, is designed for new drilling to 1500-ft. depths and for tailing-in after rotary, for drilling deeper, for swabbing, and for cleanout work, generally to 2500 ft. The machine swings 2500 lb. of tools at 1000-ft. depths and lighter tools at correspondingly greater depths. Four mountings are provided to meet all requirements.

The machine is of all-steel construction; the electric-welded main frame is 13 ft. long, with main sills 12 in. deep. The machine mounts on a truck having a standard chassis.

Reels are chain-driven and free-running, being controlled by friction clutches. The bull reel and sand reel brakes are air cooled. These two reels, as well as the calf reel, have instantaneous reverse. The bull wheel is provided with two speeds to permit swabbing and other heavy pulling besides ordinary work. The spudder is equipped with built-in patented shock absorbers with recoil control, which are adjustable to various weights of tools. The mast telescope is constructed for a safe

working load of 15,000 lb. and can be used at heights of either 40 or 50 ft.

"ATLAS"
CHROME FACE
EASY TO READ MARKINGS THAT ARE DURABLE
LUFKIN
CHROME FACE
Oil Gaging Steel Tapes
Oilmen who want a tape that's easy-to-read, that can take plenty of use and give more than the expected amount of service will be glad to know about the Lufkin Chrome Face.
These new tapes have jet black markings on satin-chrome background and are easy to read even in poor or artificial light. They're unusually free of glare. And because they're made of metal throughout are extra strong, won't crack, chip or peel. The smooth, chrome plated surface won't rust and is easy to clean. In short, they're the "last word" in steel-tapes for the oil industry.
Write for free sample of tape.
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THE LUFKIN RULE CO
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Canadian Factory
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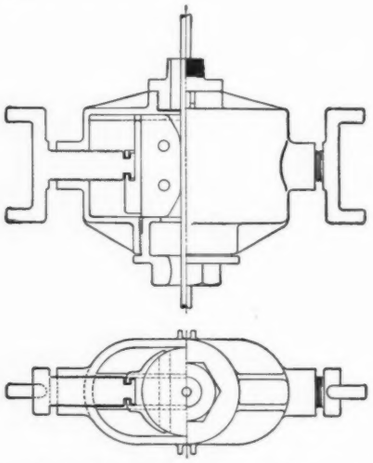
TAPES — RULES — PRECISION TOOLS

Kibele Rod Stripper

A ROD STRIPPER having adjustable packing elements that accommodate any size rod has been placed on the market by the Kibele Manufacturing Company, Dallas, Texas. Packings can be backed-off whenever it is



not desirable to strip, thus saving wear, the manufacturer asserts. Packings are either fitted closely to rods or backed-off by manipulation of screw handles that have coarse threads to permit rapid movement. The Kibele stripper also prevents escape of oil and gas while running rods in heading wells, it is stated.

The Kibele stripper connects to any size tubing or tee. All metallic parts are of steel.

Kibele also manufactures a blowout preventer that connects to female threads on the bottom of the stripper. Although operation is similar its construction differs from that of the preventer in that the latter has two retractable metal rams whose sealing surfaces are covered with thin replaceable rubber packings. The stripper and preventer in combination provide efficient protection against uncontrolled pressure surges, the makers state.

Plan Photographic Salon for A.P.I. Meeting

Plans for a Petroleum Industry Photographic Salon, sponsored by the Photographic Society of America, have been announced by the American Petroleum Institute as a feature of the association's 21st Annual Meeting scheduled for the Stevens Hotel, Chicago, Illinois, November 11 to 15, 1940. The Salon, to which photographers throughout the country have been invited to submit pictorial prints, will have as its subject, "The Petroleum Industry," and will be open to the public in the Antique Lounge of the Stevens Hotel from November 9 to 15.

The project represents a joint effort of the Institute's Committee on Public Relations and the Photographic Society of America to encourage the use of pictorial photography in presenting and interpreting modern life. The petroleum industry was selected as the subject of what the Society proposes to make a series of industrial pictorial salons because of its importance to the present mechanized civilization, the extent of its operations, and its picturesque equipment, pictorial photographing of which is regarded as a test of artistry and skill.

Members of oil-company camera clubs have been invited to submit prints for judging by the jury of selection, which is comprised of Dr. D. J. Ruzicka, Robert A. Barrows, and Edward Alenius. Closing date for receiving prints is October 15, and it is expected the judging will be undertaken about October 20. Entry blanks and information are available from F. Quellmalz, Jr., Salon Director, Room 2040, 50 West 50th Street, New York.

An advisory committee representing Institute and Society will award four honors and 10 honorable mentions to prints outstanding among those selected for hanging. Members representing the Institute on the committee are:

Chairman, John C. Day, Western Petroleum Refiners Association, Tulsa, Oklahoma; K. E. Cook, Standard Oil Company of New Jersey, New York, New York; C. C. Herndon, Skelly Oil Company, Tulsa; Leonard Timbs, National Supply Company, New York; Eben Griffiths, Socony-Vacuum Oil Company, Inc., New York; Robert Y. Ritchie, commercial photographer, New York; Philip C. Humphrey, The Texas Company, New York; and Victor H. Scales, of the Institute staff. Members representing the Society are: Chairman, Don Loving, Chicago Art Institute, Chicago; Dr. L. L. Handly, Houston, Texas; Frank Liuni, president of the Society, New York; John P. Mudd, Philadelphia, Pennsylvania; Victor Overman, Corvallis, Oregon; J. S. Rowan, Baltimore, Maryland; George Slade, Chelsea, Massachusetts; Sidney S. Smith, Shell Oil Company, Inc., St. Louis, Missouri, and Director Quellmalz.

W. J. Harradine General Manager Keystone Driller Company

Announcement has been made of the election of W. J. Harradine as a director and vice-president and general manager of Keystone Driller Company, with plants at Beaver Falls, Pennsylvania, Joplin, Missouri, and Arlington, New Jersey.

The company was recently reorganized under Section 77B of the Bankruptcy Act, and the new board of directors held its organization meeting shortly thereafter.

Harradine was previously associated with the company in an executive capacity, but during the period of reorganization was connected with the Buckeye Traction Ditcher Company in charge of the Washington, D. C., office.

SAVE REPLACEMENTS...
REDUCE DRUM WEAR...

ASBESTOS "CABLES" form the backbone of J-M 420 Rotary Lining. Woven into a compact mass, impregnated and compressed, they make a remarkably efficient and durable lining for heavy-duty work.

WITH THIS TOUGHER
ROTARY LINING

● Most drillers and owners alike are sold on the better braking performance of J-M 420 Rotary Lining. Made of a specially impregnated, improved weave of "cabled" asbestos fibers, this new-type material is unusually strong and durable . . . highly resistant to heat and shock. It lasts longer, requires fewer replacements. Feed-off is unusually even, load control is easy and sure. Rim scoring is practically eliminated. It will pay you to get full details on J-M 420 before your next relining job. Write Johns-Manville, 22 East 40th Street, New York, N. Y.

Johns-Manville
420 ROTARY LINING

Industrial Advertisers Choose Detroit for 1940 Conference

Industrial advertising and marketing executives of the United States and Canada will meet at the Hotel Statler in Detroit, September 18 to 20, for the 18th annual conference of the National Industrial Advertisers Association, it has been announced.

The conference, to which particular importance attaches this year in view of major economic changes at home and abroad affecting industry, is being sponsored by the Industrial Marketers of Detroit, local chapter of the N.I.A.A. The Toledo Industrial Advertisers Club, Toledo chapter, will act as co-hosts.

Plans for the Conference are being formulated by a general conference committee under the chairmanship of Lloyd R. Vivian, Ditzler Color Company, Detroit, and president of the Industrial Marketers of Detroit. E. C. Howell, Carboloy Company, Detroit, is vice-chairman of the conference committee whose membership includes: Henry F. Belcher, Insto Gas Company; Athel F. Denham, Denham and Company, agency; Henry G. Doering, The Truscon Laboratories; Peirce Lewis, *The Iron Age;* C. C. Mercer, Ex-Cell-O Corporation; Tom Moule, Seiler, Wolfe and Associates, agency, and Phillip Ruprecht, McGraw-Hill Book Company, Inc., of Detroit.

The PACKING with the *TWIST*

The patented process of "Twisting" aluminum or lead foil around a resilient core is one of the secrets of success of Durametallic Flexible Metallic Packing. *Often imitated — never duplicated.*

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The PERFECT SEAL

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FLEXIBLE METALLIC PACKINGS

DURA SEAL THE MECHANICAL SEAL

1 SEAMLESS
2 UNIFORMLY FULL PIPE THICKNESS
3 SELECTIVE, UNIFORM REINFORCEMENT
4 TANGENTS
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6 ENDS MARKED IN QUARTERS
7 COMPLETE IDENTIFYING MARKS ON EVERY FITTING
8 A FULL LINE

YOU pay no more for the welding fittings that alone combine these eight features.

TAYLOR FORGE WeldELLS

Seamless Pipe Fittings for Welding

TAYLOR FORGE & PIPE WORKS

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Earl E. Thulin General Sales Manager Duff-Norton

The Duff-Norton Manufacturing Company, Pittsburgh, Pennsylvania, manufacturers of lifting jacks, has announced the appointment of Earl E. Thulin as vice-president and general manager of sales. Thulin for the present will have his headquarters in the Peoples Gas Building, Chicago, Illinois. Later in the year he will be at the general offices of the company at Pittsburgh.

C. N. Thulin continues in Chicago as vice-president and will act in a sales executive capacity as a special representative in all territories.

W. I. Floyd has been appointed assistant general manager of sales in addition to his present capacity of assistant to the president, with headquarters at the general office of the company in Pittsburgh.

G-E Engineers Receive Coffin Awards

For their work in improving control equipment to perform high-power, complicated operations with speed and precision, General Electric engineers Kenneth K. Bowman, M. A. Edwards, and Francis Mohler were among those to receive recently Charles A. Coffin Foundation Awards, the highest honor conferred by General Electric upon its employees. These awards are made annually to those employees adjudged to have made the most outstanding contributions to their company and to the electrical industry.

Through the use of the Amplidyne Generator, which develops an extremely sensitive and powerful system of amplification and automatic control, Bowman, Edwards, and Mohler solved the long-recognized problem of the need for improved control in high-power, complicated operations requiring speed and precision. This development has enabled the General Electric Company to solve motor-control problems in a simpler and more accurate manner than was heretofore possible, it is stated.

An outstanding application, in the steel industry, is the electric flying-shear, which enables red-hot steel bars emerging from the mill at 2000 ft. per minute to be cut into 30-ft. lengths with an accuracy of ¼ in., without the use of any mechanical connection between the shear and the mill.

Harry O. Powell Joins Mid-Continent Supply Company

HARRY O. POWELL

After many years of continuous service in various executive capacities with the National Supply Company, Harry O. Powell has recently become associated with the Mid-Continent Supply Company, Fort Worth, Texas.

Powell is well and favorably known in the petroleum industry and is a recognized authority on oil-country pipe and casing requirements. As manager of the tubular division for Mid-Continent he will headquarter at the company's main offices, Mid-Continent Building, Fort Worth. He will cover all territories served by Mid-Continent.

Appointed General Sales Manager Coffing Hoist

The Coffing Hoist Company, Danville, Illinois, announces the appointment of Harry N. Hayes to the position of general sales manager. Hayes has been with this company for a number of years, during which time he acted in the capacity of district sales manager in various territories, with the result that he is well known in the field. Previous to becoming affiliated with the company he had many years' engineering and selling experience.

Move Pittsburgh Office

The Pittsburgh, Pennsylvania, office of the Frick-Reid Supply Corporation has been moved to 305 Ross Street, from their former headquarters at 117 Sandusky Street, North Side, Pittsburgh.

Burdette Blue Heads Public Relations Committee I.P.A.A.

Burdette Blue, president of the Indian Territory Illuminating Oil Company, Bartlesville, Oklahoma, again is chairman of the Public Relations Committee of the Independent Petroleum Association of America, it has been announced by Harold B. Fell, executive vice-president of the association.

The committee, named by Frank Buttram, associate president, is substantially the same as that which has functioned in disseminating information to the public in recent years. Frank M. Porter, vice-president, Wirt Franklin Petroleum Corporation, Oklahoma City, Oklahoma, is vice-chairman, and other members are as follows: R. A. Broomfield, Jr., Barnsdall Oil Company, Los Angeles, California; C. A. Johnson, president, Holly Oil Company, Los Angeles, California; T. C. Johnson, Wichita, Kansas; Harry Leonard, Harry Leonard, Inc., Roswell, New Mexico; R. J. Daugherty, Bartlesville, Oklahoma; R. C. Jopling, vice-president, Phillips Petroleum Company, Bartlesville, Oklahoma; Frank Long, vice-president, Oklahoma Natural Gas Company, Tulsa, Oklahoma; J. S. Noland, Barnsdall, Oil Company, Tulsa, Oklahoma; Jake L. Hamon, Cox and Hamon, Dallas, Texas; John W. Naylor, Fort Worth *Star Telegram*, Fort Worth, Texas, and Chas. A. Warner, Houston Oil Company of Texas, Houston, Texas.

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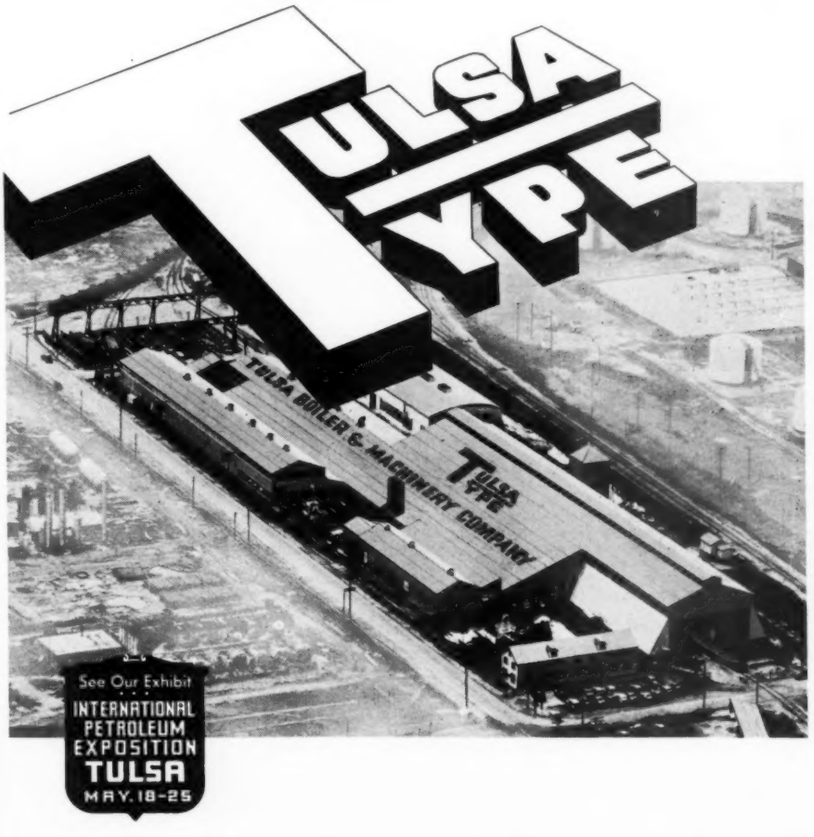
While you are here for the Natural Gasoline Convention and the Petroleum Exposition, we invite you to visit the plant where TULSA-TYPE Gasoline Plant and Refinery Equipment is *built-right!*



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GET ACCURATE
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This is the pressure gauge which tells you in sign-board figures your exact pressure at all times on your mud, water, oil, gas, or any liquid line. Because movement of the dial is minimized, a steady reading is easy at a glance from 30 feet away. It employs no Bourdon tube and screws directly on the line. The self-contained diaphgram prevents line fluid from entering any part of the gauge mechanism. The gauge is not affected by external vibrations, and pump pulsations are dampened over the entire pressure range without adjustments. It was designed and constructed specifically for oil field drilling and similar service, and has definitely taken pressure gauging out of the delicate instrument class.

Available in following pressure ranges:

POUNDS PER SQUARE INCH

0-1000 0-3000 0-5000

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0-70 0-210 0-350

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0-70 0-210 0-350

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ABERCROMBIE
PRESSURE GAUGE

A. E. Walker New President National Supply Company

A. E. Walker was elected president of The National Supply Company on April 3.

A native of Detroit, Michigan, Walker received his engineering education at the University of Michigan, graduating in 1910.

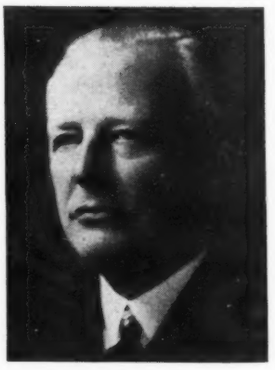
A. E. WALKER

For 21 years he was connected with the Republic Steel Corporation and its predecessor, the Republic Iron and Steel Company, serving as general manager of sales from 1928 to 1936, and was also president of Truscon Steel Company. From January, 1937, to April, 1939, he served as executive vice-president of the Pittsburgh Steel Company.

On April 1, 1939, Walker was elected vice-president and director of The National Supply Company, as well as president of Spang Chalfant, Inc., and now advances to the presidency of The National Supply Company.

New Officials American Locomotive Company

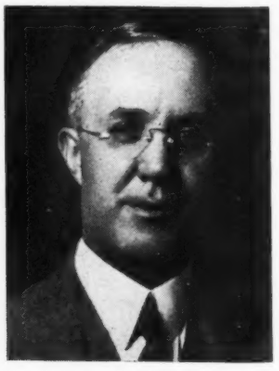
American Locomotive Company, 30 Church Street, New Your City, has announced the recent appointment of several new officials. William Carter Dickerman has been appointed chairman of the Board, Duncan W. Fraser has been made president, and Robert B. McColl has been appointed vice-president in charge of manufacturing.



W. C. DICKERMAN

Dickerman, after graduating from Lehigh University in 1896, entered the employ of the Milton Car Works, Milton, Pennsylvania. In 1899, on formation of the American Car and Foundry Company, of which the Milton Car Works became a part, he was appointed assistant manager of the Milton district. Transferred to New York

D. W. FRASER



R. B. McCOLL

in 1900, he was appointed sales agent. and later general sales agent, which position he held until 1905 when he was appointed vice-president. During the war Dickerman was in charge of the American Car and Foundry Company division, and in 1919 became vice-president in charge of all operations of the company. In 1929, he was elected president of the American Locomotive Company, which position he held until his recent appointment as chairman of the board.

Fraser served his apprenticeship at the Rhode Island Locomotive Works. In 1904, when the American Locomotive Company acquired the Montreal Locomotive Works, Inc., he was transferred to the Montreal Works where he served in various capacities until he became works manager, and later managing director of the company. In 1920 he was appointed vice-president of the American Locomotive Company with headquarters in New York. In 1924 he became a director, and in 1939 a member of the executive committee. He retained the position as vice-president until his recent appointment.

In January, 1922, McColl became attached to the New York office of the American Locomotive Company and the following June was appointed assistant manager of the Schenectady plant, and in January, 1925, manager of the plant. In 1931, he was elected president and director of the McIntosh and Seymour Corporation, Auburn, New York, a division of the American Locomotive Company, and when the former was merged with the parent company, McColl was appointed vice-president of the American Locomotive Company, Diesel Engine Division. In 1936 he was elected president of Alco Products, Inc., a division of the American Locomotive Company, and later when Alco was merged with the parent company McColl was appointed vice-president of the American Locomotive Company, Alco Products Division, which position he held until his present appointment.

U.S.C. Adds Wing to Engineering Building

Made necessary by a 50 percent increase in student attendance during the last three years, a new $125,000 wing to the College of Engineering Building on the University of Southern California campus was recently completed.

Established in 1928, the division is keeping pace with the Southern California demand for engineers, enrollment increasing from 250 in 1937 to the present student body of 385, according to Dean Philip S. Biegler.

The class A concrete structure of four stories including 27,000 sq. ft. of space, is equipped for class room and laboratory instruction in the fields of petroleum, chemical, electrical, mechanical, civil, general, and mechanical engineering. In addition to transmission lines, motors, types of pumps, boilers, and hydraulic testing apparatus, equipment is provided for fuel and field testing in petroleum problems, as well as laboratories for graduate work.

Because of the proximity of the university to the many Southern California oil fields, and the area as a center for power distribution and the rubber industry, courses are particularly popular in these fields, declares Dean Biegler.

Bachelor and master of science degrees in addition to professional degrees are offered by the U.S.C. division in the four and five year courses.

George Gude Makes Extensive Trip

George E. Gude, Jr., sales manager, Wyatt Metal and Boiler Works, Houston, Texas, has returned from a six-weeks' business trip in the North and East, including stop-overs in Pittsburgh, Pennsylvania, Cleveland, Ohio, New York City, Boston, Massachusetts, Chicago, Illinois, and Hamilton, Ontario. He was accompanied by Mrs. Gude.

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CHAIN PIPE TONGS

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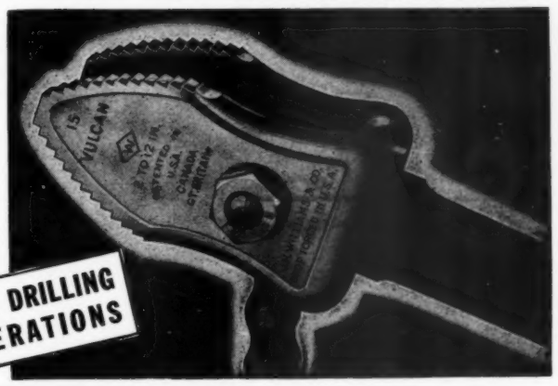
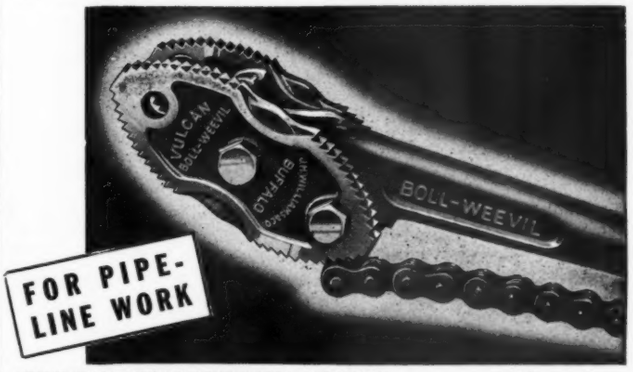


GENUINE "VULCAN" TONGS: Every part built to bear its share of the load. Chains proof-tested and certified; Jaws and Handle are tough drop-forgings; Through-bolt is extra heavy, and its U. S. Standard Nut simplifies replacement. 8 sizes with Flat Link or Cable Chain—⅛" to 18" pipe.

Also "VULCAN SUPERTONGS": *The maximum in Chain Tong Strength.* Same design but drop-forged from Alloy and High Tensile steel, heat-treated and equipped with Alloy "SUPERCHAIN." 50% greater strength than regular "Vulcan" Tongs of corresponding size and weight, 8 sizes for ⅛" to 18" pipe.



"VULCAN BOLL-WEEVIL" TONGS: A *reversible action* Tong for flat pipe work—very efficient in trenches. Changes instantly from "Making-up" to "Breaking-out" without even unhooking chain. Jaws reversible for double life. Each chain proof-tested and certified. 4 sizes, ¾" to 12" pipe.

Also "BOLL-WEEVIL ZEPHYR": *Greater strength with much less weight.* Same structural and utility features as regular "Boll-Weevil," but heat-treated and equipped with Alloy "SUPERCHAIN"—stronger and much lighter, capacity for capacity. 3 sizes, for ¾" to 12" pipe.

J. H. WILLIAMS & CO., 225 Lafayette St., NEW YORK

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Life of Metal Pump Valves Increased by Use of Composition Disks

By HAROLD H. YACKEY
Assistant Superintendent, Northern Division Pipe Lines,
Union Oil Company of California

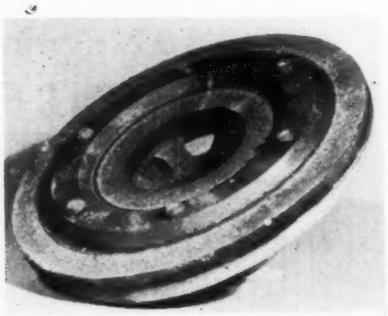

Fig. 1

THE brass pump valves originally supplied with certain main-line pumps purchased by Union Oil Company of California required refacing as often as every two months. To improve the wearing surface of these valves, disks of fabric impregnated with a synthetic resinous material were attached to the valves as shown in Fig. 1.

Equipped thus, the valves lasted much longer, some as long as a year, and slipped considerably less than the brass valves. The rivets or bolts used to hold the disks to the brass valves broke frequently, however, and in each case required that the valve be replaced.

To eliminate this objection, the valve and disk assembly was then made up with the disk unattached as shown in Fig. 2. A concentric lip was provided on the inside edge of the brass valve as a guide for the disk, the disk being held to the valve by fluid pressure.

This design very soon showed defects. Disks would be ruptured because of oil trapped between the disk and valve (see Fig. 3). This tendency was eliminated to a great extent by allowing at least 1/32 in. clearance between the hole in the disk and the lip of the valve.

HAROLD H. YACKEY

has been in the employ of the Union Oil Company of California since 1928, both in the refinery and transportation departments—Has held his present position since 1932—Makes his headquarters in San Luis Obispo, California—Has a degree in mechanical engineering from the University of Illinois.

Disks continued to rupture, however, when oil would be pocketed between disk and valve, especially on larger diameter disks. To offset this, holes were drilled through the disk and a connecting groove cut into disks between holes, and the groove side of the disk placed against the valve. Oil was thus prevented from being trapped under the disk.

Fig. 3

The disk, shown in Fig. 4, is the present design and is working very satisfactorily. Disks do not have to be renewed oftener than every two years and valves never have to be sent to the shop. Seats are sent in only when rocks or other material damage the seat. Ordinary wear is taken by the disk and the seat is not cut.

The cost of valves has been greatly reduced. Whereas, in the original design, the valve and seat eventually had to be replaced, in the new design the disk only is replaced and at a fraction of the cost.

These disks have been installed on pumps ranging from 9 by 36 to 3 by 4 liquid ends and are equally satisfactory on all sizes. On the smaller valves, holes and grooves are not necessary and in some designs the disk merely guides on the stem and no brass valve is used at all.

Fig. 2

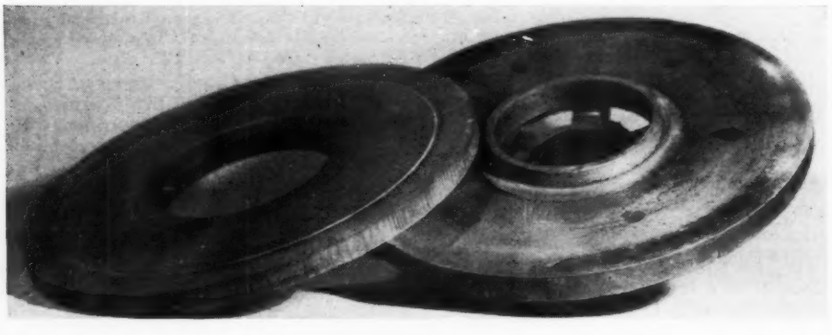
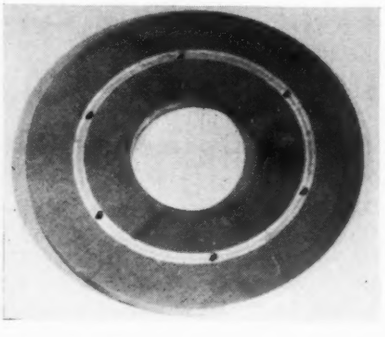
Fig. 4